MEDICAL ANATOMY:

OR,

ILLUSTRATIONS

OF THE

RELATIVE POSITION AND MOVEMENTS

OF THE

INTERNAL ORGANS.

BY

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TO

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THIS WORK IS

DEDICATED BY

THE AUTHOR.

PREFACE.

Descriptive and surgical anatomy are well taught in our medical schools, but the practical teaching of medical anatomy, or the knowledge of the relative position of the internal organs, is neglected. Indeed, on the present plan and with the existing means, it is impossible to teach that subject, which is as important for the physician as surgical anatomy is for the surgeon.

When a body is prepared for the dissecting-room, the arteries are injected from the arch of the aorta, to the injury of the great vessels. The superficial dissection of the body precedes that of the internal organs; and by the time those parts are reached, they have lost that freshness which is so necessary for their successful study. Generally, indeed, they are then in a state of decay, and their relative position has been altered.

It is impossible, therefore, that the relative anatomy of the internal organs can be taught in the dissecting-room: but the dead-house affords all the materials for their study.

It falls to the teacher of pathology to make the *post-mortem* examinations; and it would be easy for him to give practical demonstrations of the contents of the chest and abdomen in health as well as in disease. It ought, therefore, to be one important duty of that officer to teach the topographical anatomy of the healthy viscera on the dead body. Afterwards he might take the pupils into the wards or the out-patient room, and indicate to them, on the living body, the varying position of the organs during the healthy exercise of their functions. He would at the same time train them to a knowledge of the physical signs furnished by the healthy viscera. Under his tuition, the student ought to be as familiar with the position and movements of the organs as if he saw them stripped of their parietes and exposed to view.

Until this be done, it is self-evident that the teaching of clinical medicine must be imperfect.

The student naturally rivets his attention upon the subjects of his coming examination to the exclusion of everything else. He knows that his acquaintance with the anatomy of the limbs and the head and neck will be carefully tested, and that anatomy he studies. He also knows that he will not, as a rule, be examined on the bearings of, say, the great vessels, the heart or lungs in relation to the walls of the chest, or on the movements of those parts during life, or on the signs of their healthy functions. The result is, that the student does not seek to acquire, and has not the opportunity of acquiring, that kind of knowledge of which I have just spoken.

If the examiner were to require the candidate to point out accurately, on the exterior of the living body, the corresponding position and the movements of the internal organs, and the signs by which they are distinguished in health, the teacher would speedily discover the method whereby he could convey the desired information, and the pupil would eagerly avail himself of it.

This work, which consists of a series of illustrations of medical anatomy, is founded upon the Author's paper in the *Provincial Medical Transactions* for 1844 on the situation of the internal organs. That paper, in the preparation of which he received important aid from his friend, the late Dr. Hodgkin, was the result of numerous observations made by himself in the wards, and, more especially, on the dead body.

In 1848, Conradi published a valuable memoir on the position and size of the thoracic and abdominal organs. In that work, which has been translated into English by Dr. Cockle, with a view to publication, Conradi gives the topography of the internal organs as laid down by the Author in the paper just referred to. He then describes his own numerous researches by means of percussion on the living body, and compares them *seriatim* with the Author's observations on the dead.

Those researches substantiate in the main the anatomical conditions defined by the Author.

The illustrations in the earlier and larger portion of this work represent the parts exactly as they were found after death. The front, the sides, and the back of the frame, from the surface to the deepest parts, are depicted in succession.

In making these drawings, the Author employed mechanical aids, described in columns 1 and 85, by means of which he has been able to represent with precision every organ, with its external and internal relations, at each stage of the dissection.

This volume thus presents the exact topography of the parts contained in the body, from its circumference to its centre.

Accurate representations of the exterior and interior of the dead body give, however, no adequate idea of the movements and varying position of those parts during life. At the time of, and after death, indeed, the heart and great vessels and the lungs shrink upwards, the diaphragm ascends, and the stomach and liver and the subjacent organs are partially raised.

In looking, therefore, at all drawings that are literal transcripts from the parts contained in the body after death, due allowance must be made for those changes that take place during and after the departure of life.

To supply, as far as possible, this deficiency, and to represent and describe the organs in motion as they are during life, the later portion of the work is devoted to the movements of respiration, and to the movements, structure, and sounds of the heart.

The part relating to the movements of respiration developes and illustrates the papers by the Author on the "Mechanism of Respiration" in the *Philosophical Transactions* for 1846, and on the "Movements of Respiration in Health and Disease" in the *Medico-Chirurgical Transactions* for 1848.

The description of the movements, structure, and sounds of the heart is derived from numerous original experiments, observations, and dissections made by the Author during the last seven or eight years. The peculiar methods employed by him in pursuing those inquiries are described in columns 73-77, 83, 84, and 88.

These researches have been a work of great labour and deep interest to the Author. He believes that they represent important physiological truths, and he trusts that they may be useful to those who are engaged in the study of the vital phenomena of respiration and circulation.

59, BROOK STREET,

January, 1869.

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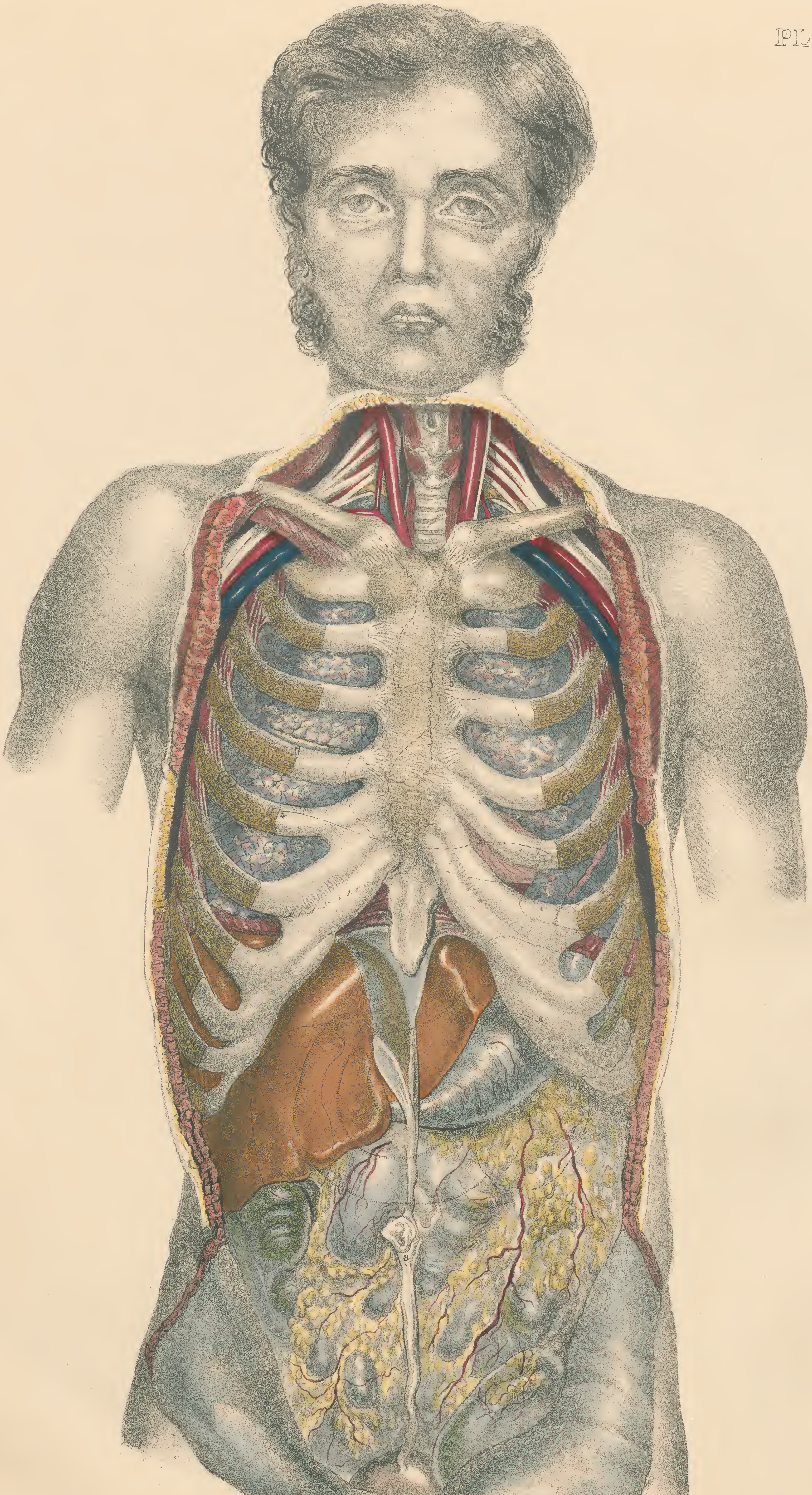

Drawn from the Subject & on Stone by William Fairland.

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COMMENTARY ON PLATES I., II., & III.

THE STERNUM, RIBS, AND CARTILAGES.—THE ANTERIOR SURFACE OF THE LUNGS.—THE SUPERFICIAL CARDIAC REGION.—THE SUPERFICIAL STRUCTURES OF THE NECK AND THE DIAPHRAGM, IN HEALTH AND DISEASE.

In Plate I. the lungs are unusually large; in Plate II. they are rather smaller than usual. This difference observed in two bodies, the internal organs in both of which were healthy, is owing to more air having been expelled during the last expiration in the one than in the other. It must always be borne in mind, that these drawings show the exact position of the organs as they were found in the bodies represented. Now, the organs do not occupy precisely the same position in the living body as in the dead. Expiration is the last act of life, and this last expiration is usually more extensive and forced than the expiration of tranquil life. In the dead body, therefore, the lungs shrink up within the position that they usually occupy during life; at the same time the heart and its vessels retract, and the abdominal organs follow the diaphragm somewhat upwards. During life the whole of the internal organs are perpetually in motion. With each inspiration the lungs and heart are lengthened downwards by the descent of the diaphragm, which, at the same time, pushes downwards the abdominal and the pelvic organs. The lungs and heart of a strong man, working vigorously, are larger than those of a weak, bed-ridden man. When a coal-heaver, by an accident, is confined to bed for weeks, his lungs shrink up to a marked extent, and his chest is narrowed and flattened. The internal organs vary, then, in position and size, within certain limits, in different individuals, in the same individual at different times, and in the same body during life and after death.

THE STERNUM, RIBS, AND CARTILAGES.

The sternum, ribs, and cartilages, with their relation to the parts immediately subjacent, are shown in Plates I. and II. In both views, the lungs are seen through the intercostal spaces, and in Plate I., owing to the removal of the diaphragm as well as the intercostal muscles, the upper part of the liver and stomach are also seen through the interspaces. These Plates show that the ribs and cartilages differ considerably in different individuals, and that they vary also in the same person on opposite sides. In Plate I. the upper ribs are near each other, while the lower are far apart; whereas, in Plate II., the upper ribs are far apart, while the lower are crowded together. In Plate I., the right upper ribs are considerably nearer to each other than the left; so much so, that the lower border of the right sixth rib is on a level with the upper border of the left sixth. The difference in the position of the ribs in these two bodies, is mainly owing to the lungs being more expanded, and the whole frame more robust and set in Plate I. than Plate II. Taken together, they illustrate the different position taken up by the ribs during inspiration and expiration. During inspiration, the clavicles, first ribs, and through them the sternum, and all the annexed ribs, are raised; the upper ribs converge, the lower diverge; the upper cartilages form a right angle with the sternum, and the lower cartilages of opposite sides, from the seventh downwards, move further asunder, so as to widen the abdominal space between them, just below the xiphoid cartilage: the effect being to raise, widen, and deepen the whole chest, to shorten the neck, and apparently to lengthen the abdomen. During expiration, the position of the ribs and cartilages is reversed; the sternum and ribs descend; the upper ribs diverge, the lower converge; the upper cartilages form a more obtuse angle with the sternum, and the lower cartilages of opposite sides approximate, so as to narrow the abdominal space between them, just below the xiphoid: the effect being to lower, narrow, and flatten the whole chest, to lengthen the neck, and apparently to shorten the abdomen. It is to be observed, that during inspiration, while the ribs and sternum are moving upwards, the lungs and heart and the abdominal organs are moving downwards, and that, consequently, viewed in relation to the ribs, the descent of the internal organs appears to be greater than it really is.

In the robust (Plate I.) the medium expansion of the chest is greater than in the slender (Plate II.); therefore, in the former the upper ribs are nearer each other, and the lower are further apart, than in the latter. In persons affected with emphysema or bronchitis, the whole chest has the fulness and form assumed by it during a deep inspiration; consequently the neck is short, the clavicles and sternum are unusually high, the upper intercostal spaces are narrow, while the lower are singularly wide and hollow, and the lower cartilages of opposite sides are far apart, so as to widen the abdominal space between them just below the xiphoid. In phthisis, on the other hand, the whole chest is narrowed and flattened as in expiration, the neck is long, the clavicles and sternum are low, the upper ribs are far asunder, while the lower ribs are crowded together, and the cartilages of opposite sides below the xiphoid approximate. That side on which the tuberculous disease is most advanced, partakes most of the expiratory character, as regards the form of the chest and the position of the ribs; the region below the clavicle being narrower and flatter, and the upper intercostal spaces wider on the diseased than on the healthy or less affected side. If one side of the chest be distended with pleuritic effusion, the whole of that side is full, rounded, and prominent, especially over the lower part; the ribs diverge so as to widen the intercostal spaces, which, instead of forming a hollow between the ribs, are level with their surface; and the edge of the seventh and eighth costal cartilages, below the xiphoid, are raised outwards, so as to leave an unusually large space between them and the linea alba. If, after the disappearance of the effusion, the lung contract, and form strong adhesions with the ribs, the whole of the affected side, assuming the expiratory form, shrinks inwards; the lower ribs are crowded together, and the space below the xiphoid, between the cartilages and the linea alba, is narrowed: while the whole of the sound side, in order to compensate for the deficiency, is unusually developed, so as to present the type of inspiration; the upper ribs converge, the lower diverge, the space below the xiphoid, between the cartilages and the linea alba, is widened, and the lower end of the sternum is drawn over towards that side.

Extensive pericardial effusion causes increased fulness over the whole pericardial region, the two lower thirds of the sternum being prominent, as well as the left costal cartilages from the second to the seventh, the whole of which are pushed farther apart from each other. If the heart be greatly enlarged, the cardiac region is unusually prominent from the fourth left cartilage and rib down to the seventh, the interspaces being generally somewhat widened. If the heart be adherent, as well as greatly enlarged, the prominence over the cardiac region is usually greater and more extensive than when the heart is enlarged without adhesions, the prominence often extending upwards to the third or second left cartilage, and sideways to the right of the sternum as well as to the left of the nipple; the intercostal spaces are widened over the region indicated, and the lower cartilages below the xiphoid are pushed outwards, so as to increase the space between them and the linea alba. The effect of heart disease on the position of the ribs and cartilages, differs mainly from that of the various lung

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EXPLANATION OF PLATE I.

This and all the following Plates were taken from dissections made by myself. I took the outlines of the organs by the aid of a transparent tracing frame, suggested to me by Dr. Hodgkin, on the plan described in my paper on the Situation of the Internal Organs in the Prov. Med. Trans. for 1844. Those outlines formed the groundwork for the coloured drawings from the body, which, as well as the lithographs, were executed with untiring care by Mr. Fairland, under my close supervision. The lithographs have been carefully coloured, from the original drawings, by Mr. Sherwin.

Plate I. was taken from a robust, well-built man, aged 37, and upwards of six feet high, who died of cholera. I am indebted to the kindness of Mr. Filliter, Surgeon to the Marylebone Infirmary, for the opportunity of making the dissection and drawing.

In Plate I. the ribs are represented in relation to the lungs, heart, and other internal organs, to expose which, the intercostal muscles, and the diaphragm, below the edges of the lungs, have been removed, after tying the trachea. In this plate the flaps are not shown as they were in the dissection, but conventional incisions have been represented, in order to exhibit the outlines of the body.

The Numbers 1 to 7 refer exclusively to a series of dotted lines which indicate the outlines of the deeper organs. The outlines of the lungs are indicated on the sternum and ribs.

1. Conjunction of the aorta, vena cava descendens and right auricle.—2. Commencement of the arteria innominata and left carotid.—3. Pulmonary artery.—4. 4. Diaphragm. —5. Stomach and duodenum.—6. Spleen.—7. 7. Kidneys.—8. Umbilicus and linea alba. (Reduced from 33 inches to $19\frac{1}{8}$ inches.)

diseases in this, that whereas the latter so modify the form of the chest in whole or in part, as to produce an effect similar to that caused by inspiration, if one or both lungs be enlarged, or by expiration, if one or both be lessened; the former diseases cause direct protrusion of the sternum, cartilages, ribs, and interspaces immediately superficial to the enlarged organ, that protrusion varying in extent and degree with the extent and degree of its enlargement. The diseases of the heart produce a much more marked effect on the parietes of the chest in youth, when the cartilages are yielding, and the sternum is still composed of several bones united by cartilage, than in adult life, when the whole frame-work of the chest is firm and unyielding.

When the whole abdomen is very much distended, whether by excessive flatus, by effusion of fluid into the peritoneum, by ovarian dropsy, or by large tumours, the diaphragm is pushed upwards, and the lower ribs and cartilages are pushed outwards, so as to cause on each side a sudden, sometimes almost angular, prominence of all the lower ribs subjected to the pressure, those ribs being crowded together in an unusual manner; and to induce extensive separation of the lower cartilages of opposite sides below the xiphoid, so as greatly to increase the abdominal space between them. If the liver be much enlarged from hepatic congestion, fatty degeneration, or any cause acting equally throughout its tissue, the organ usually finds increased space, not by pushing the diaphragm upwards, but by displacing the other abdominal organs downwards and to the left, it at the same time pushes the ribs and cartilages below the sixth outwards to an unusual extent, so as somewhat to enlarge the prominence usually present over the liver: but if a large hydatid cyst, or abscess, or malignant tumour be imbedded in the mass of the right lobe, the liver then finds its way upwards, so as to push up the diaphragm sometimes as high as the second rib: under these circumstances, the ribs and cartilages superficial to the liver are unusually and irregularly prominent, both in front and to the side; and the measurement of that side is much greater than that of the opposite side. When the stomach is excessively distended, it pushes the diaphragm upwards, the liver upwards and to the right, and all the other abdominal organs downwards; and, varying with the extent of the distension, it at the same time causes unusual protrusion of the lower left ribs and cartilages.

The *nipple* forms one of the superficial landmarks in relation both to the ribs, and the lungs, and heart. Usually the nipple is situated just over the fourth intercostal space, but it may be seated over the fourth rib as it is in Plate I., on the left side, or over the fifth rib, as it is on the right side. During inspiration, the ribs ascend much more than the nipple, hence if it be over the fifth rib during inspiration it will be over the fourth rib during expiration. On the same grounds, the ribs are higher in relation to the nipple in robust and full-chested persons, than in feeble, flat-chested persons. In emphysema, the position of the nipple is usually the same that it is during inspiration, being over the fifth rib, whereas in phthisis it is generally over the fourth rib, as in expiration. In emphysema, the sixth rib is so much raised as to be sometimes only about one inch below the nipple, while in phthisis the sixth rib may be as much as four inches below the nipple, especially on the affected side. I observed this difference recently in two patients in St. Mary's Hospital.

THE ANTERIOR SURFACE OF THE LUNGS.

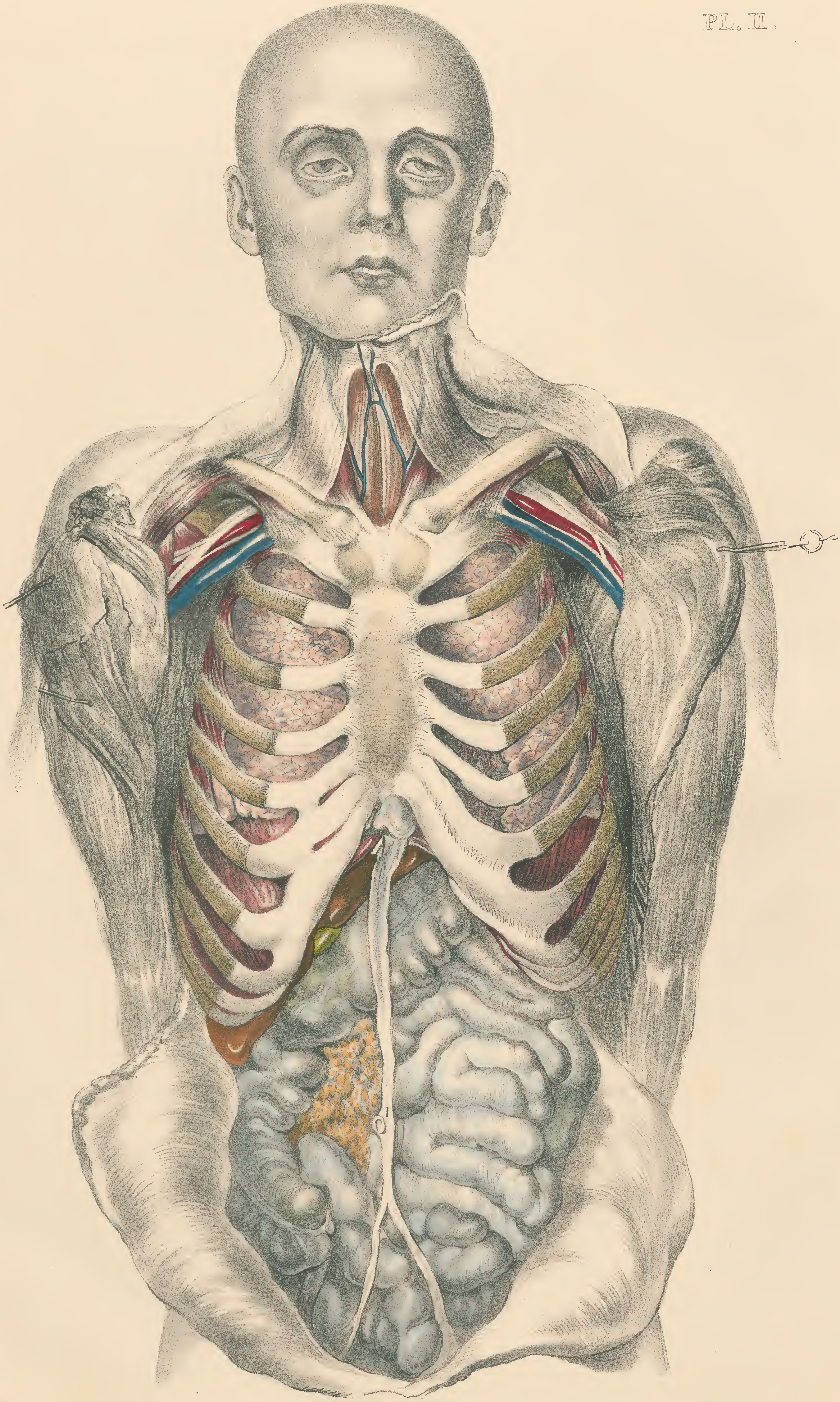
In Plates I. and II. the front of the lungs is seen through the intercostal spaces. In Plate III., the whole of the anterior surface of the lungs is exposed by the removal of the sternum, ribs, and cartilages; their relation to the lungs being still shown by a series of dotted lines traced along their outline. As I have already remarked, the lungs in Plate I. are unusually large, whereas in Plate II. they are rather smaller than usual. Plate I. is taken from a remarkably fine robust man, in the prime of life; Plate II. from a somewhat slender youth. The medium amount of air in the lungs during life has evidently been less in the latter, and he has, during the last expiration, expelled a much larger quantity of air from his lungs than the former. Plate I., therefore, more nearly represents inspiration; Plate II., expiration.

In Plate I., the inner edges of the lungs meet behind the sternum, between the first intercostal spaces, and pass down together behind that bone, a little nearer the left than the right edge, until they are opposite the head of the fifth costal cartilages: there the left lung diverges; its edge, which is immediately superficial to, and just above the heart, passes behind the fifth costal cartilage, and the fourth intercostal space, and turns directly downwards, so as to cross behind the fifth costal cartilage; it is then seen through the fifth intercostal space, where it makes a curve to the right, disappears again behind the sixth cartilage, and soon terminates in the lower edge of the lung, which takes a sloping direction to the left, immediately behind the sixth cartilage. The inner edge of the right lung continues its course behind the sternum, straight downwards, from the point of divergence, and ends in the lower edge behind the upper extremity of the xiphoid cartilage. The lower edge of the right lung takes a direction to the right and slightly downwards, from the centre of the xiphoid, crosses, behind the seventh costal cartilage, and reappears through the sixth intercostal space just below the edge of the sixth cartilage; it then crosses that interspace, keeping a line directly to the right, and passes successively behind the seventh rib, the seventh interspace, and the eighth rib. The lower edge of the left lung takes a similar course to the left, beginning from behind the sixth costal cartilage in front of the apex of the heart; it then appears through the sixth intercostal space, and crosses in succession that space, the seventh rib, the seventh interspace, and the eighth rib. A line drawn directly downwards from the nipple would cut the lower edge of the right lung, where it appears through the sixth interspace, and a similar line from the left nipple would cut the lower edge of the left lung, where it lies behind the sixth rib. A line drawn downwards on either side from the centre of the axilla would cross the lower edge of the lung where it lies behind the eighth rib. In Plates II. and III., which are both taken from the same subject, the inner edges of both lungs meet behind the sternum, between the second intercostal space, pass downwards side by side for a short distance, and diverge opposite the head of the fourth cartilage. The edge of the left lung rests upon the heart, immediately behind the fourth costal cartilage, so as to form the upper boundary of the superficial cardiac region, turns downwards at the extremity of that cartilage, and crosses the fourth intercostal space, the fifth rib, and the fifth intercostal space; as it does so, it again curves inwards towards its lower edge, which is seated behind the upper edge of the sixth cartilage, just in front of the apex of the heart. The inner edge of the right lung descends from the point of divergence, behind the middle of the sternum, a little nearer to its left margin, and ends in the lower edge of the lung just above the lower extremity of the sternum. The lower edge of the right lung crosses successively behind the sixth and fifth cartilages, the fifth intercostal space, and the sixth, seventh, and eighth ribs. The lower edge of the left lung is nearly a rib's breadth lower than that of the right lung; it at first lies behind the sixth cartilage and rib, and crosses successively behind the sixth intercostal space and the seventh and eighth ribs. I may be excused for giving, in the subjoined note, a quotation from Conradi's valuable paper on the position of the internal organs during life, as ascertained by means of percussion, seeing that they directly confirm my own previous observations, recorded in a paper on the situation of the internal organs, in the Prov. Med. Trans. for 1844.* Conradi's observations were made under the eye of Professor Vogel, who has, since the publication of the paper in question, devoted much attention to the subject in immediate connexion with clinical medicine. I hope to be enabled, through his kindness, to enrich the future parts of this work with some of Professor Vogel's valuable observations.

The septum between the upper and middle lobes of the right lung, is seen through the third intercostal space in Plate I., and lies behind the third ribs in Plates II. and III. The division between the middle and lower lobes is seen through the sixth intercostal space in Plate I., through the fifth intercostal space in Plate II. Thence it rises upwards and backwards. The septum between the upper and lower lobes of the left lung, commences behind the sixth cartilage in Plate I.; rising, it thence crosses successively the fifth intercostal space and the fourth rib. In Plates II. and III. the position of this septum is very similar. It may be noticed that, in these two subjects, the opposite lungs are not equally large: in Plate I. the left lung is altogether smaller than the right, while in Plate II. the left is the largest of the two. The result is that the left lung approximates in size and position in the two subjects, while the right lung is much larger in Plate I. than in Plate II.

The lower edge of the left upper lobe, just where it is in front of the heart near the apex, usually projects inwards, so as to form a peculiar

* "The point of divergence of the inner margin of both lungs, (behind the sternum,) lies, for the most part, at the level of the fourth or fifth left cartilage, quite in accordance with the indications of Sibson. In the mammary line, the sixth rib; in the axillary line, the eighth rib, forms the landmark for the lower margin, as well of the right as of the left lung; which also coincides with the indications of Sibson, founded on anatomical researches."—Conradi: "Ueber die Lage und Grösse der Brustorgane," &c. 1848.



tongue, or almost pointed wedge of lung. This projecting tongue is indicated in Plate I., but is present in a very marked and peculiar manner in Plate III., where it forms a return lower boundary to the superficial cardiac region.

ABNORMAL CAUSES WHICH AFFECT THE POSITION OF THE ANTERIOR SURFACE OF THE LUNGS.

The position of the lungs in front of the chest may be changed by affections of the lungs themselves, the pleura, and the bronchial glands; of the heart and pericardium, and the great vessels; and of the abdominal organs.

In emphysema, the lungs, being unusually expanded, take up the same position that they do during the deepest possible inspiration. The lower boundary of the lungs descends everywhere from an inch to an inch and a half, so that, instead of being behind the lower end of the sternum, and a line running thence across the sixth rib, it is as low as the lower end of the xiphoid cartilage and the seventh rib. At the same time the enlarged lung interposes itself between the ribs and sternum and the heart, which is drawn downwards; so that the heart is just behind, below, and to the left of the xiphoid cartilage, over which part its impulse may be felt and its sounds best heard, instead of over the fourth and fifth left intercostal spaces. In phthisis, and in lowering diseases, especially when the patient is confined to bed, the lungs gradually contract upwards, so that their lower margin may rise from the sixth rib to the fifth intercostal space; and they shrink away from before the heart and great vessels, so that the region of cardiac dulness on percussion, and the seat of impulse, are extended upwards.

In pneumonia, affecting the middle and lower lobes of the right lung, the affected lung is enlarged by the exudation which universally distends the air-cells of the affected parts, and the base of the affected lung is, therefore, unusually low. The opposite lung is, however, called into excessive play, to compensate for the deficient action of the diseased one, as well as to supply the increased demand for respiration; both lungs are, therefore, unusually large, and the bases of both are universally low. In pleuritis with effusion, the lung, as I have already said, floats forwards on the affected side, and the heart and the edge of the opposite lung are pushed over to the unaffected side. If the effusion be in the left pleural sac, the heart is pushed to the right, so that its impulse is felt in the epigastrium, or even in the right fourth and fifth intercartilaginous spaces; and the inner margin of the right lung is displaced to the right of the sternum. If the right side be the seat of the effusion, the heart is pushed unusually to the left, its apex being felt quite to the left of the line of the nipple, and the inner edge of the left lung is displaced to the left of the sternum. During the earliest stage of pleuritis, when the quantity of fluid effused is as yet inconsiderable, the friction-sound, if present, is usually heard over the sixth and seventh cartilages, just below the margin of the lungs; in fact, not over the lung itself, but over the diaphragm, which is likewise affected with pleuritis immediately below the lung. With the increase of effusion the friction-sound becomes totally lost, but as the effusion again disappears, the friction-sounds reappear, exactly over the same spot, being of a more harsh, grating, or even creaking character than they were at the onset,—the friction between diaphragmatic pleura and costal pleura being stronger than that between pulmonic pleura and costal pleura. As the fluid disappears, the friction-sounds become more extensive, and more harsh and grating, or creaking. They gradually extend upwards, sometimes reaching to the fourth, third, or even second ribs. As the fluid still lessens, harsh tactile vibrations are often present as well as the friction-sounds.

If, when the pleuritic effusion totally disappears, the lung remains permanently condensed, and is universally and strongly adherent to the ribs, the opposite lung becomes permanently enlarged, to compensate for the deficiency; and its inner margin finds its way over into the opposite side of the chest; so that, if the right lung be contracted, the inner margin of the left lung may encroach an inch or even more to the right of the sternum. At the same time, the heart, which, when the effusion was at its height, was pushed entirely over to the unaffected side, is now sometimes displaced almost entirely into the affected side, so as to make way for the sound, amplified lung. Thus, in the case just supposed, of permanent contraction of the right lung, the impulse may be felt, not to the left but to the right of the sternum. The parallel history and state of things was present in a case of effusion into the left pleura published in my paper "On the Movements of Respiration in Disease," in the Med. Chir. Trans., 1848.

In pericarditis, the effused fluid, which gravitates backwards, is at first insufficient to displace the lungs from before the pericardium. As the effusion increases, however, it pushes the lungs more and more aside, so that the exposed pericardium, when distended, lies immediately behind and to each side of the sternum, as high up as the second costal cartilages. The pericardium then assumes a conical form, the cone pointing upwards. If the fluid increase slowly to a very large extent, the pericardium becomes excessively widened, especially to the left, so that it pushes the whole of the front of the left lung so far backwards as to be out of sight when the chest is opened. The left lung may be thus displaced upwards as high, even, as the clavicle. When the heart is enlarged, it does not encroach upwards on the lungs, which are generally amplified, but makes way for itself downwards and sideways; the impulse being low and far to the left, if the left ventricle be enlarged; and behind the lower sternum and xiphoid, if the right ventricle be enlarged. When the heart is adherent, as well as enlarged, it not only makes its way downwards, but it also encroaches on the lungs upwards, as high as the third or even second left rib, and sideways, to the right of the sternum as well as to the left of the nipple.

In aneurism of the arch of the aorta, the lungs are displaced from behind the upper part of the sternum, the displacement sometimes extending to the right, sometimes to the left, according to the extent and direction of the aneurism.

When the abdomen is unusually distended, from whatever cause, whether from flatulent distension, ascites, ovarian dropsy, or large abdominal tumours, the diaphragm, as I have said before, is raised, and the lungs and heart are crowded upwards into the chest to an extent proportioned to the distension. Sometimes the lower margins of the lungs are raised as high as the fourth ribs. When the flatus is expelled, or the dropsical effusion is removed, the diaphragm and lungs descend to their usual place, with immediate relief to the shortness of breath, the palpitation, the congestion of the head and face, and the sense of suffocation caused by the distension. If the stomach and intestines be unusually empty, owing to starvation, whether from want of food, or inability to swallow, owing to disease of the œsophagus, or to retain food, owing to scirrhous pylorus, the diaphragm, and with it the lower boundaries of the lungs and heart, descend to a marked extent.

If, as I have already said, the liver be simply enlarged, it usually pushes the intestines downwards, instead of displacing the diaphragm, and the lower margin of the right lung upwards. Should, however, a large abscess, hydatid cyst, or tumour occupy the upper part of the liver, the diaphragm and the lower boundary of the right lung are raised, sometimes as high as the second or third rib, whilst the heart is also raised and pushed over to the left, so as to encroach on the cardiac margin of the left lung.

EXAMINATION OF THE ANTERIOR SURFACE OF THE LUNGS DURING LIFE.

The extent, volume, and condition of the anterior surface of the lungs, may generally be ascertained with precision during life, by observing the form of the chest, and the movements of breathing, by percussion, by ascertaining the seat of the heart's impulse, by auscultation, by noticing the extent of the vocal vibrations, and by measuring the chest. This is the order in which I think it best to make those observations.

The broad outlines and mass of the lungs may be appreciated with an approach to accuracy, by carefully observing the *form of the chest.* The examination of the chest ought, indeed, to commence with this inquiry. If, as I have already indicated, the whole chest be broad, deep, and full; if it be raised towards the neck, and shortened towards or raised from the abdomen, we may safely infer that the lungs are capacious. If, on the other hand, the whole chest be narrow and flat; if it be lowered from the neck, and lowered and lengthened towards the

EXPLANATION OF PLATE II.

This Plate and Plates III., IV., V., VI., and VII., were taken from a youth, aged 18, who died suddenly in a fit. The dissections and drawings were made at St. Bartholomew's Hospital School, through the kindness of Mr. Paget and of Mr. Holden, who, with Mr. Holmes Coote, gave me valuable assistance during the progress of the drawings.

Plate II. represents the same view as Plate I., except that the diaphragm is not removed, and the flaps are represented as they were in nature.

1. Umbilicus and linea alba. (Reduced from 32 inches to 19 inches.)

abdomen, we may infer that the lungs are contracted. The size of the upper lobes may be accurately inferred by the fulness, flatness, or hollowness of the chest below the clavicles, within the head of the humerus, and in the axillæ. Any difference in the degree of fulness on the two sides over the upper lobes, is readily appreciated by the eye just below the clavicles, and by the hand just to the inside of the head of the humerus, and in the axilla. If the upper lobe be full, a single finger can scarcely be interposed between the head of the humerus and the second rib, or be inserted into the axilla when the arm is at the side; but if the lobe be contracted as well as flattened, two fingers can be readily pressed inwards, by the side of the humerus, or be inserted into the axilla.

The normal lower boundary of the middle lobe of the right lung is indicated by a depression commencing at the lower end of the sternum, and thence crossing in succession the seventh and sixth costal cartilages. The sixth, seventh, and eighth intercostal spaces are convex where they are over the lung, but plane where they are over the liver; since the latter organ, being solid, supports them, while they are forced inwards over the lung by atmospheric pressure. The margin of the lung may be inferred by noticing the lower limit of the depression in each interspace. During inspiration, owing to the descent of the lung and the downward displacement of the liver, as well as the increased atmospheric pressure, the depression in each interspace is deepened, and its limit descends, *pari passu*, with the descent of the margin of the lung, so that the exact inspiratory descent of the lung may be thus recognized. The same remark applies to the lower boundary of the left lung, but with much less precision, since the heart supports the intercostal spaces superficial to it, while the stomach does not support the interspaces so well as the liver.

In Emphysema, the depression of the lower intercostal spaces is not only deepened in degree, owing to the increased atmospheric pressure, but in extent also, owing to the great expansion of the lung downwards. In cases of enlarged liver, or of great abdominal distension, the lower intercostal spaces are no longer depressed, owing to the extent to which the lower boundary of the lung is pushed upwards. The ribs, from the seventh downwards, usually form a prominence on each side over the liver and stomach. These prominences, which indicate the lower boundary of the lungs, and the upper boundary of the liver and stomach, and which are more marked in Plate II. than in Plate I., may be readily felt by pressing the hands firmly on each side, and bringing them from the axillæ downwards, when they will feel the prominences in question, and be stopped by them, especially by that over the liver, which is usually fuller than that over the stomach, unless that organ be distended. The abdominal organs, just below the lungs, have a larger circumference than the lungs themselves; hence the fulness in question over the liver and stomach, which was first pointed out by the late Dr. Edwin Harrison. When a deep inspiration is taken, the circumference of the lungs increases from two and a half to five inches; hence the prominences over the liver and stomach are obliterated by a deep inspiration, and hence they are less marked in the robust, as in Plate I., than in the weak, as in Plate II., owing to the medium size of the lungs being larger. For the same reason, the prominences over the liver and stomach are almost or altogether obliterated in emphysema, while they are unusually full, especially that over the liver, in phthisis, owing to the enlargement of that organ, as well as the contraction of the lungs.

The *movements of breathing* are present wherever the lung can expand. The extent of the respiratory movement indicates with precision the amount to which the lungs, or any part of them, is capable of expansion. In a future commentary I will return to this subject.

By *percussion* we ascertain the extent and volume of the lung with greater precision than by any other means. Those other means are not, however, to be neglected for this reason, since, as we shall see presently, on some occasions, percussion totally fails us in our endeavour to ascertain the limits of the lung. In some persons, also, the surface is so morbidly sensitive, especially over the seat of disease, that percussion is rendered impossible or inefficient. Besides this, the nature of many cases is involved in doubt, in spite of the combination of all the possible aids towards diagnosis. We cannot, therefore, afford to part with or neglect any of those means that may enable us more thoroughly to comprehend the case. At the same time, I may remark, that the examination of the patient ought always to be made with an exclusive regard to the welfare of the patient. It ought not to be carried to the extent of increasing the sufferings of the patient merely to gratify a scientific curiosity, or to make an over-refined diagnosis.

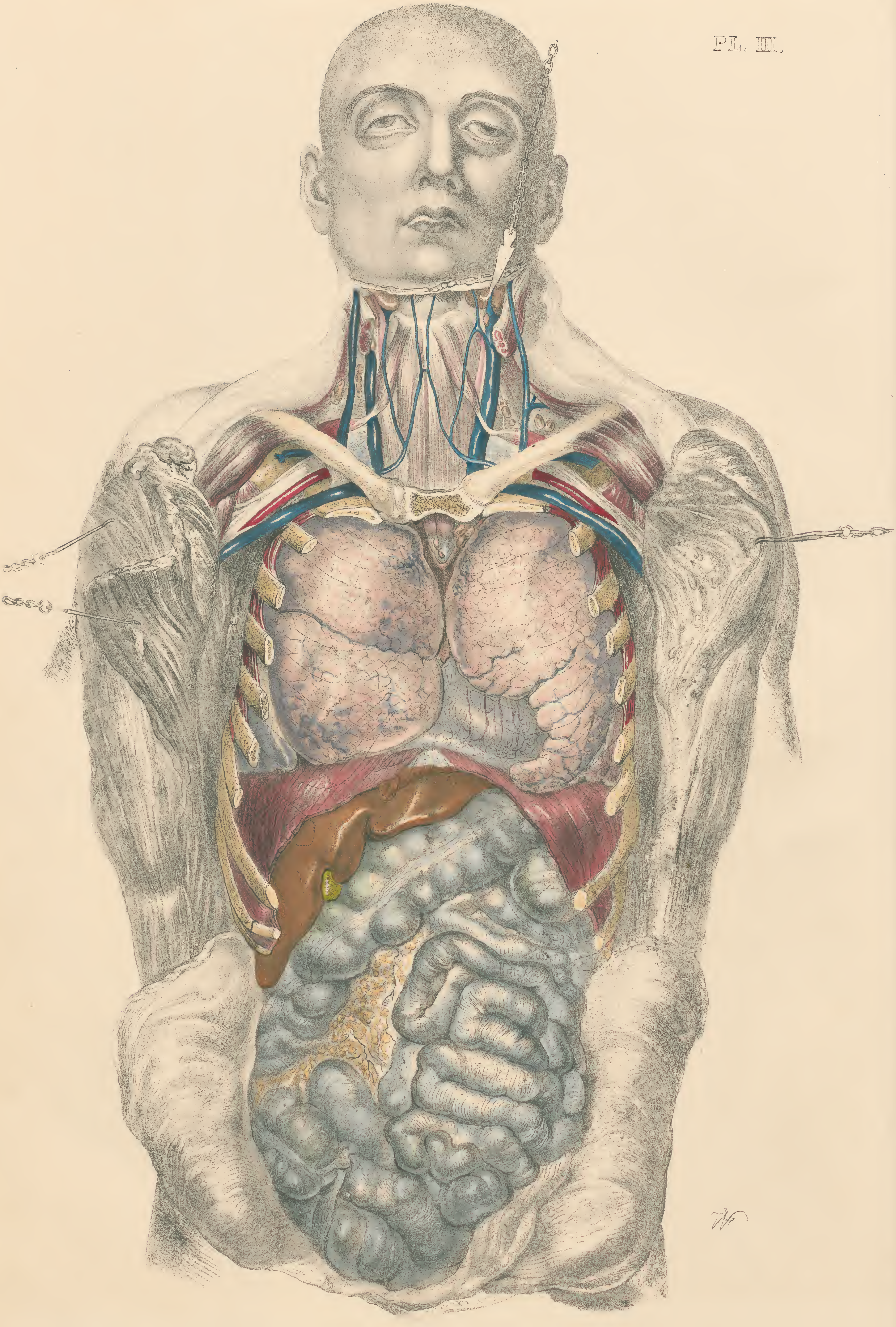
The exact boundary of the lungs may be very quickly ascertained by making a few light taps over the lower boundary of the right and left lungs, and over the border of the left lung, just above the superficial cardiac region. The percussion must, at those places, be made with a very light stroke, else the resonance excited by the superficial and thin film of lung will be immediately deadened by the subjacent mass of solid liver or heart; or be rendered unduly resonant and amphoric by the distended stomach. The same remark applies also to percussion over the sternum, since the whole bone forms a sounding-board, which, when struck forcibly at any part, imparts its vibrations to the whole of the lung tissue behind it, whether at the part immediately subjacent to the point percussed, or at a greater distance. In fact, if percussion be made forcibly over the lung, just superficial to the liver or heart, the sound excited is dull, when it ought to be resonant; and if percussion be made forcibly over the sternum, immediately over the heart, the sound excited is resonant, when it ought to be dull.

If a person in health be desired to take a deep breath, and to hold it, after the exact lower boundary of the lung above the liver, the stomach, and the heart is ascertained, it will be found that the lower margin of the lung will descend everywhere from an inch to an inch and a half, and that the upper region of liver and heart dulness and of stomach resonance will be replaced by lung resonance. In fact, the diaphragm draws the lower boundary of the lungs, and of the heart also, downwards, to the extent indicated, during a deep inspiration; and therefore, in the nature of things, percussion is no longer made over the liver, stomach, or heart, but over the lungs, which encroach upon the solid organs, and are, at the same time, increased in circumference, owing to the augmented area of the chest. The extent, therefore, to which lung resonance is excited by percussion is not only greatly increased, but, if the percussion stroke be made with force, the lung resonance is everywhere much louder than before. During a deep inspiration, as I have just said, the heart is drawn downwards by the diaphragm to the extent of an inch, and at the same time the sternum and cartilages in front of the heart advance an inch forward, so as to deepen the area of the chest to that extent. The lung, therefore, not only occupies the place occupied by the heart previously to its descent, but it also encroaches forwards over the heart itself, so as to interpose a thicker layer of lung between that organ and the ribs. The effect is, that the region of cardiac dulness on percussion entirely disappears from over the sternum, ribs, and cartilages, and is only present over, below, and to the left of the xiphoid cartilage, and over a small portion of the seventh cartilage. The superficial cardiac region is, in fact, lowered and narrowed, so that, instead of its diameter being two inches from above downwards, and three inches from the centre of the sternum to the apex, it is now but one inch from above downwards, and an inch and a half from side to side.

The lungs, as I have already said, are more capacious, and contain, therefore, a larger medium amount of air in the robust, as in Plate I., than in the feeble, as in Plate II. It will be at once comprehended, that in the robust the heart is more shielded by lung from the sternum and cartilages than in the weak, although in the strong the heart is decidedly larger than in the weak. This is actually the case in Plate I., from a robust man, in which the superficial cardiac region is both decidedly lower in position and smaller in extent than in Plate II., from a slender youth. When a person is long confined to bed, the lung contains a smaller medium amount of air, and the superficial cardiac region ascends and increases in extent, owing to the shrinking away of the lungs from before the heart; the extent of cardiac dulness on percussion will, therefore, increase upwards in such persons, although the heart itself be smaller in size.

The extent and force of the *heart's impulse* varies with the extent of the superficial cardiac region. In the strong, owing to the great expansion of the lungs, as we have just seen, the superficial cardiac region is small and low, and, although the heart itself is large and powerful, the heart's impulse is either feeble or imperceptible. In the feeble, on the other hand, as I have just said, owing to the contraction of the lungs from before the heart, the superficial cardiac region is raised and extended; and, although the heart be comparatively small and feeble, the heart's impulse is strong and sharp, and it is felt in the third and fourth, and sometimes also the fifth interspace. If the lungs shrink away from before the heart as high as the second intercostal space, so as to expose the pulmonary artery, a peculiar, short, sharp, diastolic im-

PL. III.



pulse is felt in the second intercostal space, exactly synchronous with the second sound. This diastolic impulse is often felt in phthisis, when the lungs shrink away from before the roots of the great vessels. The increased extent of the heart's impulse is not of itself then a sign of enlarged heart, but often, on the contrary, of a lessened and enfeebled heart, as well as of a contracted lung. The chief exception to this rule is in adherent pericardium with enlarged heart, when the extent and force of the impulse is unusually great, both upwards, downwards, and sideways. When the increased impulse is from the mere exposure of the heart, the impulse, while it is increased upwards, is lessened downwards; and it is never felt so far outwards as the left nipple; but when the impulse is increased from enlargement of the heart, though it is increased downwards, it is often lessened upwards, owing to the encroachment of the lung on the upper part of the heart.

By *auscultation* we can ascertain the extent of the surface of the lungs, since the breath-sound is heard over the whole of both lungs, quite down to, but not below, their lower margins. But by auscultation we can neither define the boundaries of the lungs, nor ascertain their volume, so well as by percussion. The breath-sound is louder at the top of the sternum, and above and below the clavicles, especially the right clavicle, than it is over the sides of the chest below the scapulæ; yet the volume of the lung is much larger and its expansion greater in the latter regions than the former. Indeed, the loudness of the breath-sound is in the inverse ratio of the volume of the lung. Thus, it is universally loud and sharp, both during inspiration and expiration, over the lungs of a child, while it is remarkably soft and feeble over the lungs of the large-chested, robust man; especially, as I have just said, over the sides and back, where the volume and expansion of the lung are greatest; and where, indeed, though the soft inspiration sound can be readily heard, the expiration sound is so faint as to be heard with difficulty, even with the closest attention. As a rule, the breath-sound is louder the nearer it is to the larynx, trachea, or larger bronchiæ. For this reason, both the inspiration and expiration breath-sounds are louder below the right than the left clavicle; the breathing is, there, in fact, more bronchial in character. If we desire the patient to pant, the short, quick breathing then exerted is much more audible than tranquil breathing over the whole chest, but especially over those parts which are remote from the larynx, or large bronchiæ. It is quite evident to me that the tranquil breath-sound originates in the larynx, whence it is conveyed to the air-cells by the walls of the tubes and by the current of inspired air, being at the same time reinforced by consonating vibrations in the current of air itself, and in the walls of the tubes which convey it; but the panting breath-sound is actually excited in the air-cells and capillary bronchial tubes immediately underneath the ear. If we listen over the liver, heart, or stomach, within an inch of the lower margin of the lungs, and desire the person to take a deep breath, though the breath-sound is absent at first, it becomes distinctly audible towards the end of inspiration, when the lower margin of the expanding lung descends below the point of observation. The presence of healthy breath-sound is the most convincing proof of the healthy and permeable condition of the portion of lung examined; while the absence of healthy breath-sound, whether it be, or be not, replaced by bronchial breathing, rhonchi or frottement, is one of the most conclusive proofs of its unhealthy or impermeable condition.

If the lungs be large and full, as in the robust (Plate I.), so as to cover the greater part of the heart and to form a thick layer over the great vessels, the heart-sounds are feeble, although the heart itself be large and powerful; for the same reason that, under like circumstances, the region of superficial cardiac dulness, on percussion, is small, and that the impulse is rather feeble, or altogether absent, between the intercostal spaces. If, however, as in the feeble, the lungs be small and contracted, so as to expose the greater part of the heart, and to form but a thin layer over the great vessels, then the heart-sounds are loud, and are transmitted to a great extent over the front of the chest; for the same reason that, under the like circumstances, the superficial cardiac region and the impulse are increased upwards. The heart-sounds are heard thus extensively over the front of the chest, because the lungs are thinner, and being somewhat more condensed in tissue, conduct the sounds to the surface better than in the robust, with capacious lungs; besides this, the sternum and cartilages over the heart themselves consonate with the heart-sounds, and the continuous sternum, cartilages and ribs convey the sounds over a considerable portion of the chest.

Vocal vibrations are perceptible over the whole surface of the lungs, but not over the adjoining organs—the heart, liver, and stomach. The boundaries of those organs, where they adjoin the lower margins of the lungs, as well as those margins themselves, may, therefore, be defined by observing the extent of the vocal vibrations. Vocal vibrations are more extensive over the lower part of the chest, at the beginning than at the end of a vocal expiration, owing to the shrinking upwards of the lower edge of the lungs. If the middle or lower lobe of the right lung be hepatized, we cannot distinguish liver from lung by percussion; but we can do so by observing the vocal fremitus which is present with unusual intensity over the lung, but not at all over the liver. Under the like circumstances, bronchial breathing will be heard over the lung, but not over the liver. By these tests we can readily distinguish whether the dulness on percussion over the usual region of the lung, be owing to condensation of the lung itself, or to the encroachment of the liver upon the lung. If dulness at the base be due to pleuritic effusion, the vocal vibration will be intense over the mammary region, and absent over the scapula, when the patient lies upon the back; but if he be gently turned over on his face, the hands retaining their place, the seat of the vocal vibration will change places, and instead of being felt over the front of the chest, it will be perceived over the dorsum—the lung, in fact, being floated towards the back, owing to the fluid occupying the depending part, which is now the face. This test of the presence of pleuritic effusion is much more easy of application than the equally certain test of the change in position, under the like circumstances, of the seat of resonance or dulness on percussion.

The vocal vibrations are stronger or weaker, in proportion to the mass of the lung, and to its proximity to, or distance from, large bronchial tubes. They are markedly stronger over the right than the left infra-clavicular space; hence, if the vocal vibration be more marked below the right clavicle, it is no sign whatever of tubercular or pneumonic consolidation of the right upper lobe; but should the vibration be stronger below the left clavicle, it is quite otherwise, and there is reason to suspect consolidation of the left upper lobe. The vocal vibrations are stronger over the right than the left mammary region; and they are also stronger over both nipples than they are over the layer of lung superficial to the liver, heart, and stomach.

THE SUPERFICIAL CARDIAC REGION.

The superficial portion of the pericardium which, being uncovered of lung, is in contact with the walls of the chest, is seen through the intercostal spaces, in Plates I. and II., and is exposed fully to view in Plate III. The superficial cardiac region is not, as these Plates show, triangular, but is irregularly quadrangular. On three sides, it is framed by lung, and on the lower side by diaphragm and liver and stomach. The inner or right side, behind the centre of the sternum, is straight, being bounded by the inner margin of the right lung. The outer or left side is curved, a concave edge of the left lung being, as it were, carved out so as to adapt itself to the play of the convex surface of the heart near the apex. The remarkable tongue or horn-like wedge of lung, previously described, which completes this concave border below, is well seen in Plate III., and is evidently so arranged, that it can be pushed aside during each systole, while it will return again of itself to fill up the space vacated by the heart during each diastole. The upper side, bounded by the margin of the left lung, and the lower side, by the diaphragm, are slightly oblique in direction, and are about one half longer than the inner and outer or right and left sides. The superficial cardiac region is usually about three inches in diameter from right to left, and about two inches from above downwards. As I have already said, more than once, this region varies considerably in different persons, being smaller and lower in the robust, as in Plate I., than in the slender, as in Plate II. In emphysema it is very small and low, being quite behind and below the

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EXPLANATION OF PLATE III.

From the same body as Plate II. The sternum, and the ribs, and cartilages, in front, are removed, so as to show the anterior surface of the lungs and the superficial portion of the pericardium. Plate III. represents the superficial organs. (Reduced from 32 inches to 19 inches.)

xiphoid. In phthisis it is usually extended and raised. Its size, in fact, is in the inverse ratio of the size of the lung. Plates IV., V., and VI. will represent the exterior of the heart, and the interior of its right and left cavities; I shall, therefore, return to the superficial cardiac region when I describe the heart in connexion with those Plates.

SUPERFICIAL VIEW OF THE NECK.

The neck is shorter during inspiration than expiration, owing to the raising of the sternum and the lowering of the head. It is short in the robust, Plate I.; long in the slender, Plate II. It is short in those affected with emphysema; long in those affected with phthisis.

Many of the structures of the neck are of practical interest in a medical point of view. The larynx and trachea, the pharynx and œsophagus, and the thyroid body, are the seat of medical, in contradistinction to surgical, diseases. The veins, arteries, glands, fasciæ, muscles, and nerves of the neck, afford important signs and symptoms in various diseases of the internal organs.

The *superficial jugular vein* is usually but just perceptible in perfect health, when we are in a state of repose. During each expiration, however, it partially fills, and becomes distinctly visible, just above the clavicle. There is more blood in the vein during expiration, owing to the increased resistance to the return of the blood into the auricle, and the increased force with which the blood is propelled. When we lie down, owing to the influence of gravitation, the vein contains more blood than when we sit or stand. The vein always fills from below upwards, but in health it is never seen to mount over the lower edge of the sterno-cleido in a person at rest.

During the acts of speaking, singing, and coughing, the superficial jugular swells up, so that it is usually distinctly seen above, as well as below the edge of the sterno-cleido. This is particularly well seen in singers on the stage. The force with which they utter each note can be measured by the amount of fulness of the veins of the neck. When we hold our breath, and strain, or lift a weight, the veins of the neck and head, quite up to those of the forehead, become swollen.

During each systole, the blood meets with increased resistance when it flows from the veins into the auricle, while it is propelled along the arteries and capillaries with greater force and volume. There is, therefore, more blood in the veins during systole than diastole, and a slight systolic pulsation is visible, below the sterno-cleido, in the superficial jugular, in thirty-nine persons out of forty, when they lie down. This venous pulsation is more evident during expiration than inspiration, because the veins are then fuller.

The superficial jugular contains more blood when we are warm than cold. When persons are excited, and when the brain is very active, the blood is sent along the carotids with increased force and volume, the face flushes, and the veins of the forehead and neck swell. When violent efforts are made by a person in anger, the face is red and swollen, and all the veins are immoderately distended.

Whenever there is obstruction to the flow of blood through the heart or lungs, owing to disease in either of those organs, the superficial jugular is unusually full of blood, especially during expiration. If the obstacle to the flow of blood be excessive, as in extreme bronchitis, the veins are immoderately and equally distended, during both inspiration and expiration.

When the veins are abnormally swollen, but not distended, they are more full during systole and still more so during expiration, and the venous pulsation, which is present in the healthy, becomes unusually marked. If, however, the obstacle to circulation through the chest be so excessive, that the veins are equally distended during both inspiration and expiration, venous pulsation is no longer visible.

If disease be seated in one side only of the chest, the jugular is fuller on that side than the other. The reason of this is evident when the veins of one side are compressed by enlarged glands, by pleuritic effusion, or by a tumour, but not when there is disease of one lung.

When the brain is diseased, or unduly excited, the veins of the forehead and neck are often unusually full.

Whenever the jugular is visible above the lower edge of the sterno-cleido in a person at rest, it is either a sign that there is some obstruction to the flow of blood into the auricle, or that an undue quantity of blood is sent to the head.

When the *platysma myoides* is in action, it draws down the lower lip, and so widens the mouth. This action is sometimes put in force when persons gasp for breath, owing to extreme obstruction to respiration, and it presents a most formidable and threatening symptom.

The *sterno-cleido-mastoid muscles* are usually at rest, but they act whenever respiration is difficult. Their action is indicated by the double ridge and deep hollow which they form just above the sternum, during each inspiration.

The *omo-hyoid muscles* form the two outer borders of a broad, triangular fascia, which stretches across the front of the neck; the base of which is attached to the clavicles and sternum, the apex to the hyoid bone; and which comprises within it the sterno-hyoid and thyroid muscles. This fascia is stretched on each side, and rendered tense by the action of the omo-hyoid muscles, aided by that of the sterno-hyoid and thyroid, whenever we speak, cough, or make any expulsive or other violent effort. This fascia, and that connected with the sterno-cleido-mastoid muscles, evidently form a wall of support for the deeper veins of the neck, when those veins are in a state of unusual tension during any violent effort.

I shall consider the deeper parts of the neck in the Commentary on Plates IV., V., and VI., which will present deepening views of the neck.

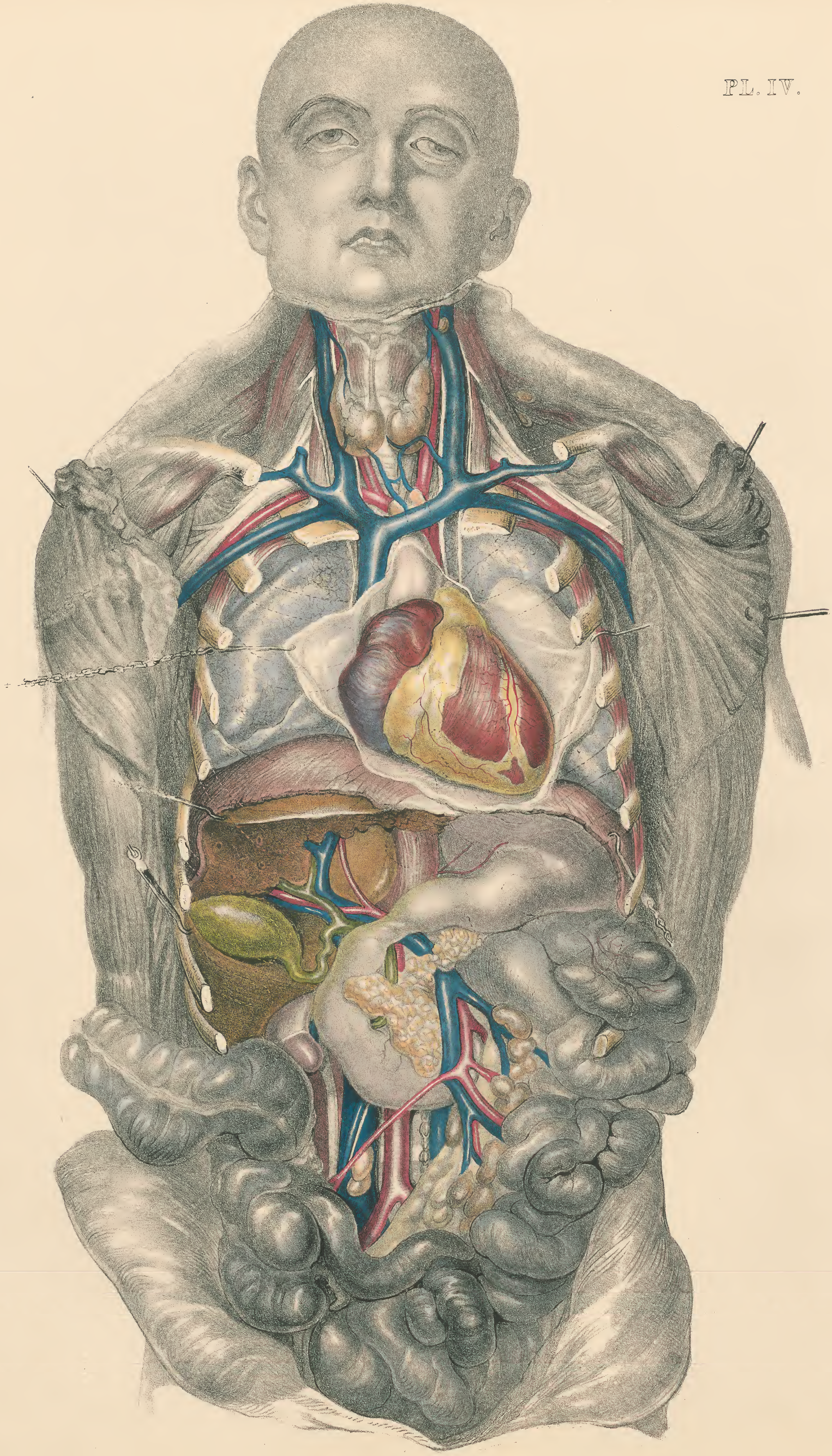
ANTERIOR PORTION OF THE DIAPHRAGM.

The diaphragm plays the most important part in modifying the position of the internal organs, whether in the chest or abdomen. I shall not now consider that important muscle as a whole, seeing that in later Plates it will be more completely exposed, and its functions more directly illustrated. I may here remark, however, that in relation both to health and disease, the diaphragm must be regarded in a double point of view. It is active during inspiration, when it descends, lengthening and expanding the lungs and heart, and pushing downwards all the abdominal and pelvic viscera. It is passive during expiration, when it is pushed upwards by the action of the muscles of the abdomen, with the effect of compressing upwards the lungs and heart. The diaphragm is also passive when it is raised or lowered by the abdominal organs, in proportion as they are large or small, full or empty; every meal, every evacuation, produces some such effect; hence the oppression in the chest, caused by a full meal or by flatulent distension, and hence the great relief afforded by a free evacuation.

In Plate I. the lungs are large, and the extent of the diaphragm below their lower edge is therefore small, while in Plate II. the lungs are rather small, so that the extent of diaphragm below their margin is comparatively large. In pleuritis, as I have already observed, the friction-sounds are often audible over the diaphragm, just below the lung, when they are not audible over the lung itself. This is owing to the superior pressure exerted by the diaphragm, and to the breath-sounds or rhonchi heard over the lung, which tend to mask the friction-sounds.

I am particularly desirous that the muscular fibres of the diaphragm should be noticed, which, in Plates I. and II., pass obliquely upwards from the seventh cartilage, cross the abdominal space below the diaphragm, and disappear behind the xiphoid. The pleura is reflected at the lower edge of those fibres of the diaphragm, and the cavity of the chest descends, therefore, thus far. During a deep inspiration these lower fibres of the diaphragm shorten and descend, and they draw down with them the lung on the right side, and the heart and lung on the left side. The ascending anterior left fibres, and, to a less extent, the corresponding right fibres of the diaphragm, are, as is shown in Plate III., inserted into the lower edge of the pericardium, the base of which is, in fact, formed of the central tendon of the diaphragm. During a deep inspiration, the fibres in question draw down the central tendon of the diaphragm and, with it, the heart, so that their lower boundary, as well as that of the right lung, are brought down as far as the lower end of the xiphoid cartilage. In fact, during inspiration, the chest, owing to the descent of the diaphragm, encroaches upon the abdomen, which, in turn, encroaches upon the chest during expiration. I would here remark upon the great extent to which, in Plates II. and III., the abdomen encroaches upon the chest. The ribs, in addition to forming the framework of the chest, overlap a great portion of the abdomen. The extent to which they do so is less during inspiration than expiration; less in the robust than in the slender; less in the patient affected with emphysema than with phthisis. During inspiration the lower ribs rise upwards, so as apparently to lengthen the abdomen and to shorten the chest: in fact, however, it is quite otherwise, since the invisible diaphragm, while it descends, really lengthens the chest and shortens the abdomen, both chest and abdomen becoming at the same time more voluminous.

I shall consider the abdominal organs in the Commentary on Plates IV., V., and VI.



COMMENTARY ON PLATES IV., V., & VI.

THE PERICARDIUM.—THE HEART AND GREAT VESSELS. MOVEMENTS AND DISPLACEMENTS OF THE HEART IN HEALTH AND DISEASE. EXAMINATION OF THE HEART DURING LIFE.—THE ABDOMINAL ORGANS.

THE PERICARDIUM.

The Pericardium besides being a reflected serous membrane is a strong fascia or fibrous aponeurosis. This aponeurosis, as may be seen in Plates III. and IV. and in Figures 1 and 2, originates in the central tendon of the diaphragm, which forms indeed the floor of the pericardium, passes upwards enveloping the heart, and is inserted into and strengthens the great vessels. The pericardium is in fact one of the aponeurotic insertions of the diaphragm. When the diaphragm descends it stretches, lengthens, and widens the pericardium, lowers the heart, and through the medium of the pericardium exerts a direct strain upon the great vessels.

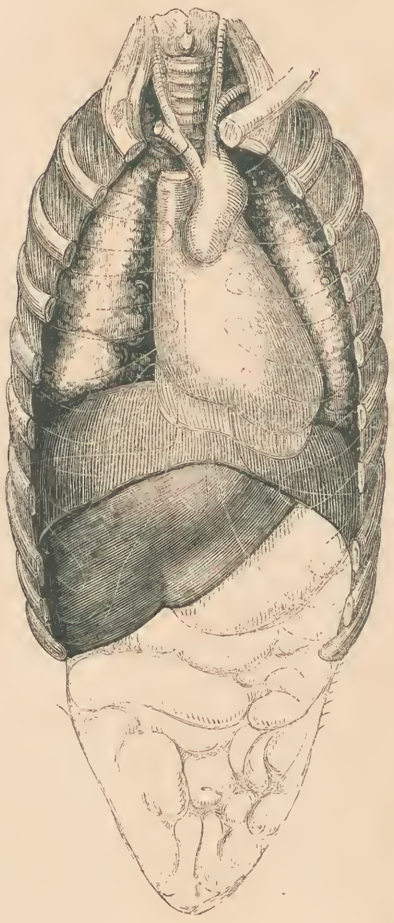


Fig. 1.
Pericardial sac flaccid.

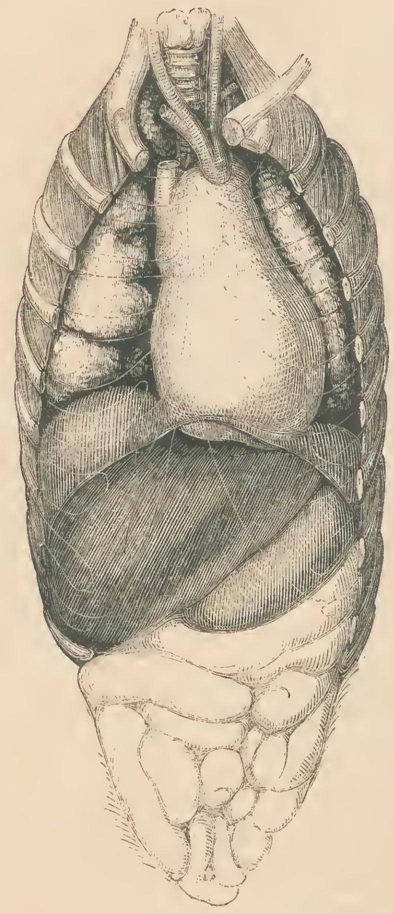


Fig. 2.
Pericardial sac distended.

The extent to which the pericardium is superficial, is seen in Plates I., II., and III. This superficial pericardial region varies much in different individuals. In general it extends from the fourth left cartilage to the sixth, and from the centre of the sternum to within an inch of the nipple. In the robust, Plate I., the lungs cover the pericardium to a greater extent than in the slender, Plates II. and III.

In pericarditis the friction sounds are first heard over the superficial pericardial region. In the robust, therefore, and still more in those affected with emphysema, the region of *frottement* in the early stage of pericarditis, is lower and more limited than in the slender, the bedridden, or the phthisical. If, in such cases, the heart be displaced to either side by pleuritic effusion, or pushed upwards by abdominal distention, the seat of the friction sound corresponds to the changed position of the heart.

In every case of pericarditis, the amount of serum in the pericardium is increased. At first this does not show itself, since the fluid gravitates backwards. As the effusion increases it distends the pericardium, which displaces the lungs and surrounding organs, and comes more extensively into contact with the parietes.

The effect of increased effusion on the form of the pericardium, is shown by comparing Figs. 1 and 2. In Fig. 1 the pericardium is flaccid, in Fig. 2 it is artificially distended with water. The swollen pericardium is pyriform. It is composed, as it were, of two spheres, the smaller, which surrounds the great vessels, resting as an apex upon the larger. The upper part of the sac displaces the lungs to each side and comes into immediate contact with the sternum, as high as the first intercostal space.

The increased effusion pushes downwards the central tendon of the diaphragm, which forms a globular protrusion into the abdomen and displaces the liver and stomach.

In a case of pericarditis with extensive effusion, the region of increased dulness on percussion over the pericardium presents the pyriform outline just described, and extends upwards in a characteristic peaked form to within an inch of the top of the sternum, sideways to the right of the sternum and left of the nipple, and downwards to below the xiphoid cartilage.

Fig. 3.
Chronic Pericarditis with extensive effusion.

From twelve to eighteen ounces of fluid can be injected into the healthy pericardium. In acute pericarditis the amount of effusion cannot much exceed that quantity. In chronic pericarditis more than three pints of fluid have been found in the sac. The pyramidal or peaked form of the region of pericardial dulness, so characteristic of acute pericarditis, is absent when, as in Fig. 3, the disease is chronic. The pericardium in fact yields, sideways, under the increasing pressure of the fluid, and encroaches so far on the left lung as to push it backwards, almost out of sight. The liver and stomach are at the same time displaced downwards, to a great extent, by the descent of the central tendon of the diaphragm. Hence the epigastric prominence and the pain on pressure in the epigastrium, sometimes observed in cases of pericarditis. While the increasing effusion into the pericardium displaces the lungs, liver, and stomach, it also causes, especially in the young, prominence of the lower sternum and adjoining left costal cartilages, and widening of the left intercostal spaces.

When the effusion is very extensive it presses backwards and upwards on the bifurcation of the trachea, causing extreme dyspnœa. In such cases, relief is experienced by sitting up and leaning forward in bed, when the pressure on the trachea is removed by the gravitation of the fluid downwards and forwards. Difficulty in swallowing has been observed in some cases. This has no doubt been caused by the pressure, backwards, of the fluid on the œsophagus where it lies between the pericardium and the dorsal vertebræ.

The effusion, while it presses outwards on the surrounding parts, reacts within the sac on the heart itself and the great vessels. The heart is attached, above and behind, by means of the great vessels. The fluid, therefore, interposes itself between the lower surface of the heart and the central tendon of the diaphragm. While the central tendon is pushed downwards, the heart is pushed upwards. The impulse, the

EXPLANATION OF PLATE IV.

From the same subject as Plates II., III., V., VI., VII.

In the neck, the sterno-cleido and the sterno and omo-hyoid have been removed, exposing—the thyroid bodies and the jugular veins.

In the thorax, the lungs have been reflected back, exposing—the heart and pericardium, and the diaphragm.

In the abdomen, the anterior portion of the liver has been removed, and the small intestines have been reflected to one side; the arch of the colon to another, exposing—the stomach, the pyloric extremity of which is contracted, the duodenum, the gall-bladder, and ducts, the vena porta, the head of the pancreas, and the termination of the ilium in the caput cœcum.

The outlines of the ribs and sternum are indicated by dotted lines. (Reduced from 32 inches to 19 $\frac{1}{10}$ inches.)

friction sounds, and the tactile vibrations, are sometimes present as high as the first, second, and third left intercostal spaces.

The effusion scarcely affects the action of the ventricles, but it doubtless compresses the right auricle, and impedes the flow of blood into it from the cavæ, thereby causing fulness of the veins of the neck.

HEART AND GREAT VESSELS.

In the dead body, the heart and great vessels shrink upwards more than half an inch, as may be seen by comparing the lower edge of the heart with the lower surface of the pericardium in Plates III. and IV.

The auricles form the right side of the heart, the ventricles the left.

Every portion of the left cavities is behind and a little to the right of the corresponding portion of the right cavities. The right auricle is in front of the right half of the left auricle. The right ventricle is in front of the left half of the left auricle, and the right two-thirds of the left ventricle. The tricuspid valve is in front and a little to the right of the mitral valve. This arrangement is reversed in regard to the great arteries and their valves. Thus the pulmonary artery and the pulmonic valves, are in front and to the left of the aorta and the aortic valves.

The left ventricle has to perform the principal work of the heart. Its axis forms the true pivot of the heart, and its walls are much stronger than those of the right ventricle, which accommodates itself in every way to the left. The left ventricle is cone shaped. The right ventricle wraps round the anterior two-thirds of the left, so that the ventricular septum, which forms the concave anterior wall of the left ventricle, forms the convex posterior wall of the right ventricle.

The axis of the right ventricle in relation to the pulmonary artery is almost vertical, the ventricle being broadest at the part most distant from the artery. The axis of the left ventricle is almost horizontal, the ventricle being narrowest where it is most distant from the aorta.

The heart and great vessels, viewed as a whole, occupy the centre of the chest, and fill up in great part the space between the sternum and the vertebræ. The ventricles encroach more on the left lung, the auricles and great vessels more on the right lung.

The apex of the heart, which is always also the apex of the left ventricle, usually points behind the fifth, sometimes the fourth intercostal space, somewhat within the line of the nipple. In health the apex and the outer wall of the left ventricle project to the left of the right ventricle. But when, as in emphysema and in mitral regurgitation, the right cavities are greatly enlarged, the right ventricle sometimes completely covers the left, even over the apex. On the other hand, when, as in aortic narrowing or regurgitation, and in many cases of Bright's disease, the left ventricle is greatly enlarged, its apex and adjoining walls protrude to a very large extent beyond the right ventricle.

In Plate IV., the heart and great vessels are rather higher than usual, and the origin of the great vessels corresponds with a line running across the sternum and along the lower edge of the second cartilages. In Plate I., the heart is rather lower than usual, and the origin of the great vessels corresponds with the line of the third cartilages. In the accompanying Figures 4 and 5, this line runs along the top of the third cartilages.

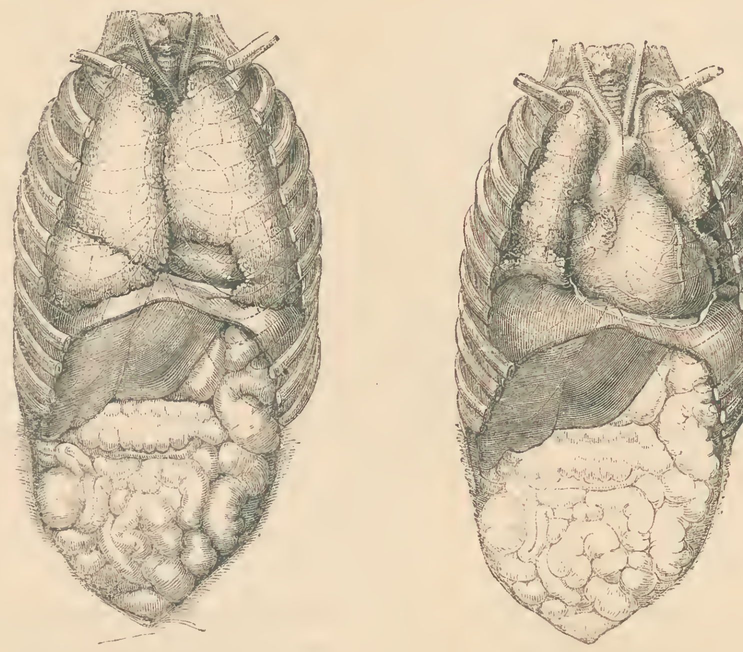


Fig. 4. Superficial view. Fig. 5. Deep view.
Position of the Internal Organs in a healthy adult male.

The right auricle lies to the right, the right ventricle to the left of

the sternum. The right auriculo-ventricular junction crosses obliquely from the left of the sternum above, to the right of it below. This junction is much more to the left when the auricle is full, as in Plate IV., than when it is empty. The tricuspid valve which is shown in Plate V. is immediately to the left of the lower half of the sternum. The valves of the pulmonary artery are usually behind the second intercostal space.

The left auricle, as may be seen in Plate VI., occupies the middle of the chest, just between the lungs, to each of which it is attached by the pulmonary veins, just below the division of the trachea. Through this attachment the heart enjoys definite relations with the lungs and shares their movements. The left ventricle lies to the left of the left auricle, extending downwards and forwards to the apex. The mitral valve (Plate VI.) is just behind and to the left of the tricuspid, while the aortic valves are behind and to the right of the valves of the pulmonary artery.

The great vessels lie side by side in the centre of the chest. The aorta is in the middle behind the upper portion of the sternum, the pulmonary artery lying to the left, the vena cava to the right. The pulmonary artery, being short, encroaches less on the left lung than the vena cava does on the right lung.

In the dead body, the aorta is flaccid, as in Plates IV. and V., and does not present the appearance of an arch. But when it is injected, or stuffed with wool as in Plate VI., the arch is more manifest.

The innominata is exposed, crossing the trachea above the sternum in Plates IV., V., and VI.; while it is concealed by the sternum in Plate I. In Figures 4 and 5 the innominata is partly above, partly behind the top of the sternum.

The superficial cardiac region has been already described in relation both to the lungs and the pericardium. The heart is usually in immediate contact with the walls of the chest, from the fourth to the sixth left cartilages, and from the centre of the lower half of the sternum to within an inch of the nipple. This space is usually three inches from side to side, and two inches from above downwards. The right or anterior ventricle lies immediately underneath the hand when it is applied over the superficial cardiac region. When this region is small, low, and narrow, as in the robust, and in those affected with emphysema, the left ventricle is wholly covered by lung even during systole; and the diffused impulse sometimes felt over and to the left of the lower sternum, or of the xiphoid cartilage, is entirely due to the systole of the right ventricle.

When the superficial cardiac region is of moderate extent, the left ventricle is superficial during systole; and the strong beat felt near the nipple, is due to the impulse of the apex of the left ventricle, which thrusts aside the small tongue of lung, already described, and comes into immediate and forcible contact with the fifth or fourth intercostal space.

When the superficial cardiac region is extensive and high, as in the slender, the bed-ridden, and the phthisical, the exposed portion of the left ventricle, the appendix of the right auricle, and the origins of the aorta and pulmonary artery, are all superficial. During systole, the strong impulse of the apex and the diffused impulse of the right ventricle are usually felt. The systolic impulse is often followed by a peculiar sharp diastolic impulse, or fillip, which is synchronous with the second sound, and is felt in the second left intercostal space, just over the pulmonary artery.

MOVEMENTS AND NORMAL DISPLACEMENTS OF THE HEART.

The comparison of Plates I. and IV. and of Figs. 4 and 5, with each other, shows that in health the position of the heart is not always the same.

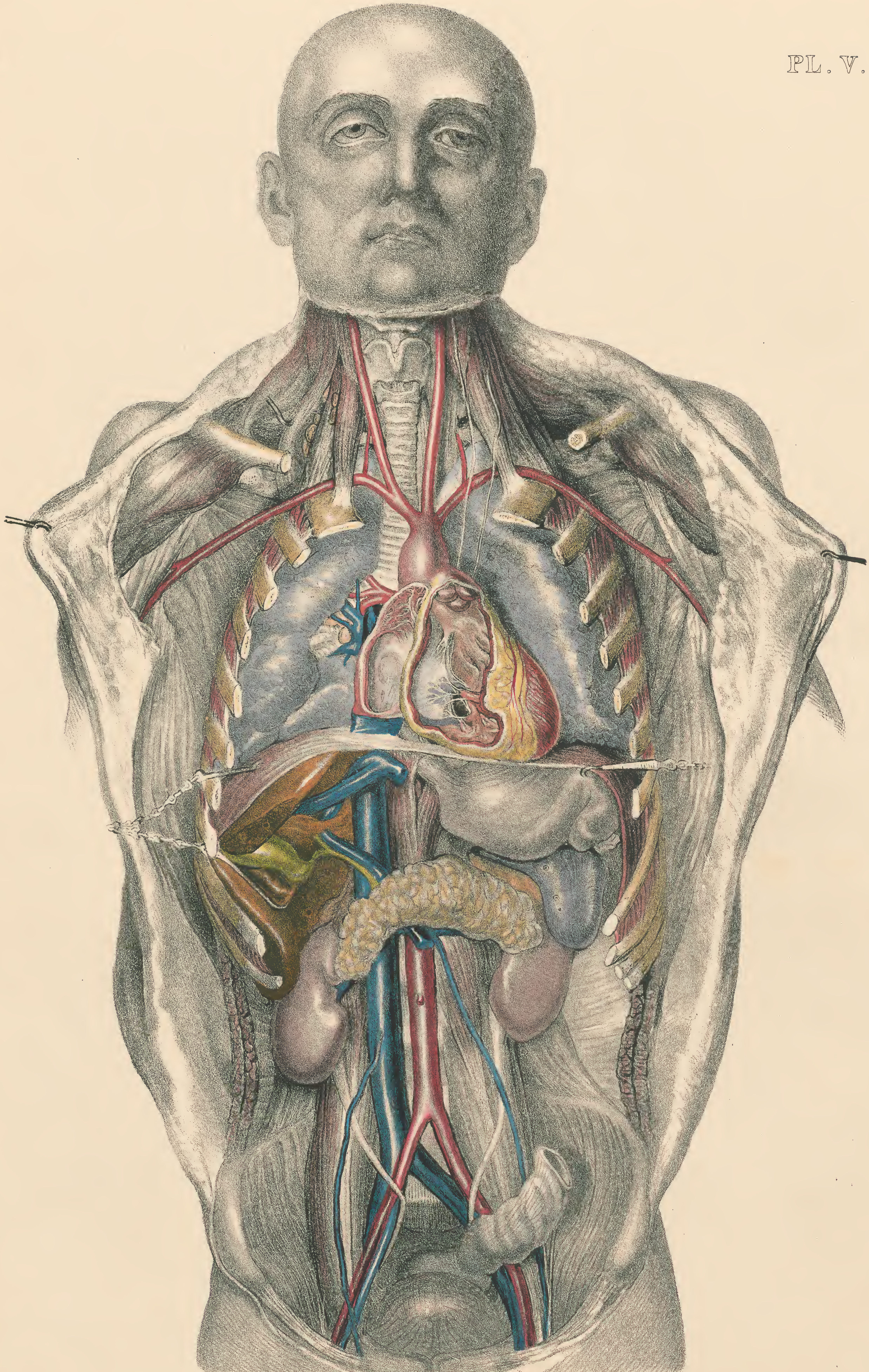
The heart is indeed itself in perpetual motion, it partakes of the constant rhythmical movements of respiration, and it is subject to displacement by the normal alterations in the size and situation of the abdominal organs, and by changes in the position of the body. There is, therefore, a constant but orderly change in the position of the various parts of the heart in relation to each other, and of the whole heart in relation to the surrounding organs and the parietes.

Active or automatic movements of the heart.

I observed these movements, during four hours, on an ass subjected to the Wourali poison, the circulation being maintained by artificial respiration. (Prov. Med. Trans. vol. xii.)

During systole, while the ventricles empty themselves, the auricles become filled. The auricles therefore displace the ventricles to some extent. The right auricle, while being filled, moves an inch from right

PL. V.



to left at its ventricular edge, while the right ventricle, during its contraction, necessarily moves to the same extent from right to left, at its auricular edge. The left auricle, being filled from behind forward, lifts up and tilts forward the left ventricle at its auricular attachment.

The right ventricle, while it moves from right to left, becomes narrowed and flattened. The left ventricle, while it advances, becomes firm and pointed; the base gradually approximates to the apex; and the posterior wall contracts and advances, while the anterior wall, or ventricular septum, bulges forwards. The left ventricle contracts with a twisting motion. The axis of each ventricle, which during diastole is in the direction of the corresponding auricle, is totally changed during systole, being then directed towards the aorta and the pulmonary artery respectively.

The aorta and the pulmonary artery move downwards during systole along with the adjoining walls of the respective ventricles.

The impulse of the apex of the left ventricle, as I have already said, is felt in the fifth or fourth intercostal space, about an inch within the line of the nipple. That of the right ventricle, when present, is perceived over and to the left of the lower end of the sternum.

The impulse of the apex is caused by a combination of forces. These forces are—the lifting up and tilting forward of the left ventricle by the distention of the left auricle behind it—the recoil of the left ventricle, when the blood is propelled into the aorta, as Dr. Alderson first demonstrated—the straightening and lengthening of the filled arch of the aorta—and the tension of the ventricular walls. So beautifully is the heart adjusted that these various forces, as well as those concerned in the impulse of the right ventricle, instead of conflicting with each other, all aid in producing the common result.

When we listen over the heart to the friction sounds of pericarditis, it is important to bear in mind the part of the heart examined, and the nature and extent of its movements.

Over and to the left of the lower portion of the sternum, we hear the friction sounds of the left ventricle, the systolic sound being the most harsh. To the right of the lower part of the sternum and over the middle of the sternum we hear the to and fro sounds of the right auricle, which are equally smooth during both systole and diastole. Over the upper portion of the sternum we hear the *frottement* of the aorta and pulmonary artery, which is louder during systole. Over, and above the region of the apex beat, the friction sound, caused by the left ventricle, is alone heard during systole, that ventricle being then only brought into contact with the parietes.

All these sounds are developed with increased intensity if we make pressure, over the heart, with the stethoscope; when, indeed, friction sounds are often excited that were previously absent, owing to the roughened surfaces being then pressed together, which were previously separated by the effusion.

Movements of the heart and great vessels caused by respiration.

During a deep inspiration the central tendon of the diaphragm descends about an inch, and draws downwards the heart and great vessels to the same extent. The sternum and ribs are at the same time raised. The apparent descent of the heart and great vessels viewed in relation to the ribs is therefore greater than the actual descent. Every part of the heart ascends thus during inspiration, and descends during expiration. During a deep inspiration the lower boundary of the right ventricle may be below the lower end of the xiphoid cartilage, and the opening of the pulmonary artery may be as low as the fourth left cartilage. During a forcible expiration, on the other hand, the lower edge of the right ventricle may be above the lower end of the sternum, and the origin of the pulmonary artery may be as high as the lower edge of the first rib. It is indeed necessary that the whole heart should thus travel up and down in the chest with the respiratory descent and ascent of the lungs, seeing that the heart is fixedly attached to the lungs by means of the pulmonary veins.

The great vessels in the neck are subject to the same respiratory ascent and descent as the heart. Thus the innominata, which may be entirely above the sternum during expiration, sinks entirely behind that bone during inspiration, when the sternum is itself raised while the arteries are lowered and stretched. This is well seen and felt in a patient now in St. Mary's Hospital. The innominata thrills with a visible beat above the sternum during each expiration, but during inspiration the artery sinks while the sternum rises, and its beat is no longer perceived.

In some anæmic persons, especially when the upper chest is prominent, a loud whirring *bruit* is heard towards the close of each inspiration over the scapular end of the clavicle. In one case the noise was obliterated and the pulsation at the wrist arrested when the patient drew a deep inspiration. This remarkable phenomenon, which may lead to the mistaken diagnosis of subclavian aneurism, is evidently due to the tightening and compression of the artery where it bends over the first rib, seeing that during inspiration the artery is stretched downwards while the rib is raised.

During expiration, the lung shrinks away from before the heart, which is itself raised; consequently the superficial cardiac region is raised and extended, the seat of the impulse is correspondingly increased, and the heart's sounds are heard over a great part of the chest. During inspiration the superficial cardiac region is lowered and narrowed so as to be quite below the sternum, being seated to the left of the xiphoid cartilage; the impulse is felt only in the epigastrium, and owing to the thickened layer of lung above and in front of the heart, its sounds are no longer audible over the whole front of the chest.

In thin persons, and in those affected with phthisis, the lungs collapse, the heart is raised and extensively exposed, the superficial cardiac region and the seat of impulse are correspondingly raised and extended, the innominata rises above the sternum, and the heart-sounds are heard over the whole chest. In the robust, on the other hand, and still more in those affected with emphysema, the heart is lowered, a thick layer of lung covers the heart and shields it everywhere from the ribs, the cardiac region and the seat of impulse are lowered and narrowed, the innominata completely sinks within the chest, and the heart sounds are only heard to a slight extent over the front of the chest.

Displacement of the heart from changes in the abdominal viscera.

When the stomach is much distended, it raises the diaphragm and pushes upwards the heart and lungs. The same effect is induced by distention of the colon or small intestines. The cardiac region and the seat of impulse are raised and extended upwards, and the heart-sounds are heard extensively over the chest. If, on the other hand, the intestines be empty, as in Plate I., the diaphragm is lowered, the heart and lungs descend, the superficial cardiac region and the seat of impulse are lowered and narrowed in extent, and the heart-sounds are feeble or inaudible over a great part of the chest.

In many dyspeptic persons, palpitation and dyspnœa, and in some angina or even syncope, are occasioned by a flatulent meal, owing to the pressure exerted on the heart by the distended stomach.

Change in situation of the heart from changes in position of the body.

The heart changes in position with every movement of the body; it falls over to the left when we lie on the right side, to the right when we lie on the left side; it ascends when we lie down, and it is lowered when we sit up. The position of the superficial cardiac region, the impulse and the heart-sounds, changes with the change in position of the body.

It is evident, from what I have just said, that there is no absolutely fixed position, in relation either to the parietes or the surrounding organs, for any part of the heart. Thus it is the narrow expression of a mere dead anatomy to say, that the pulmonic valves are situated either behind the second or the third left costal cartilage. In the broader view of a truly vital anatomy it may be said, that during the varied actions of healthy life the pulmonic valves may be present either behind the

EXPLANATION OF PLATE V.

From the same subject as Plates II., III., IV., VI., and VII.

In the neck, the veins have been removed, exposing—the arteries, and the summits of the lungs.

In the thorax, the anterior walls of the right auricle and ventricle have been removed, exposing—the interior of the right auricle and ventricle, and the tricuspid and pulmonic valves.

In the abdomen, the intestines have been removed, and the left lobe of the liver has been cut away, exposing—the cardiac orifice of the stomach—the solid organs, the liver, pancreas, spleen, and kidneys, in relation to each other, and the caval, portal, and hepatic veins.

The outlines of the ribs and sternum are not traced, but they can easily be replaced by the mind's eye, by comparing this Plate with Plate IV. (Reduced from 32 inches to 18½ inches.)

second or fourth left cartilage—may be in immediate contact with the sternum, or may have interposed between it and that bone a thick layer of lung—may lie behind the sternum, or to the left of the second or third left cartilage. The same in fact may, in principle, be said of every part of the heart, which presents an extensive, but orderly, variety of position in different persons, and in the same person at different times. The same, also, may be said of the great vessels, both at their immediate origin from the heart, and at their distribution in the upper part of the chest, and lower part of the neck.

In a practical point of view anatomy is of no use unless it can be realized on the living body.

EFFECT OF DISEASES OF THE HEART AND GREAT VESSELS ON THE SIZE AND POSITION OF THE ORGAN.

Dilatation and hypertrophy of the left ventricle may be caused by the narrowing of the aortic aperture or insufficiency of its valves, or by any cause, such as Bright's disease, producing general obstruction to the systemic circulation.

Dilatation and hypertrophy of the right cavities may be induced by disease of the valves of the pulmonary artery; by any cause, such as emphysema, producing general obstruction in the pulmonary circulation; or by mitral regurgitation, which operates by inducing dilatation of the left auricle and resistance to the circulation through the lungs.

Active dilatation of any cavity of the heart may in fact be caused by permanent resistance to the action of that cavity, from whatever cause.

Active dilatation of all the cavities of the heart may be induced by combined mitral and aortic valve-disease. This general enlargement of the heart may also be caused by mitral regurgitation, which induces, in succession, enlargement of the left auricle, the right ventricle, the right auricle, and the left ventricle.

When the left ventricle is largely dilated and hypertrophied, the impulse at the apex is felt with unusual force in the sixth instead of the fifth intercostal space, and to the left instead of the right of the line of the nipple.

When the right cavities only are enlarged, the right ventricle encroaches on and covers the whole left ventricle so as to prevent the impulse of the apex from being felt. When the right ventricle is actively dilated by mitral disease, a strong and diffused impulse is felt over the lower end of the sternum and the xiphoid cartilage, and the adjoining left cartilages. When the right cavities are dilated, owing to emphysema, the heart is lowered, the enlarged lungs cover the heart and shield it from observation down to the lower end of the sternum, and the impulse of the right ventricle is felt over, below, and to the left of the xiphoid cartilage. The epigastric impulse of the right ventricle is stronger and lower during inspiration than during expiration.

When the whole heart is greatly enlarged, adhesions not being present, it does not encroach on the lungs upwards, but it makes its way downwards and sideways; the impulse of the left ventricle is felt to the left of the nipple, and in the fifth and sixth intercostal spaces, and that of the right ventricle, over and to the left of the lower end of the sternum and the xiphoid cartilage.

When the heart is adherent as well as greatly enlarged, it not only encroaches on the surrounding organs downwards and sideways, but upwards also, as high perhaps as the second cartilages; and the superficial cardiac region, the seat of impulse, and the prominence in the heart, are proportionately increased.

When the heart is simply enlarged, the superficial cardiac region and the seat of impulse are extensively lowered and narrowed during a deep inspiration, but this is not the case when the heart, besides being enlarged, is extensively adherent. The lungs cannot then interpose themselves during inspiration between the heart and the parietes, and the impulse is but slightly lessened in extent and force. This non-diminution of the seat of impulse during inspiration is the chief characteristic of enlargement of the heart with adhesions. The intercostal spaces over the right ventricle are drawn inwards during systole in such cases, but they are equally so when the right ventricle is simply enlarged. When the ventricle is adherent as well as enlarged, this systolic retraction of the intercostal spaces is maintained during inspiration, but it is not so if there be no adhesions.

When the arch of the aorta is affected with aneurism, the artery is lengthened as well as widened; the heart is lowered in position, the left ventricle being enlarged; the lungs are displaced to each side to an extent proportioned to the size and situation of the aneurism; and the bifurcation of the trachea and the œsophagus are sometimes compressed backwards between the tumour and the dorsal vertebræ.

When the aorta and great vessels are atheromatous, the affected vessels are both dilated and elongated. Consequently, while the arch of the aorta is long and bulging, the subclavians, carotids, and all the affected vessels, are tortuous and visible. The innominata rises above the sternum. The subclavian is sometimes so tortuous as to cause a pulsating tumour over the first rib, which may readily be mistaken for subclavian aneurism, especially if there be a systolic bruit there during inspiration. The left ventricle is enlarged, and the heart is usually lowered in position.

EFFECT OF DISEASES OF THE LUNGS AND PLEURA ON THE SIZE AND POSITION OF THE HEART.

In phthisis, the lungs shrink upwards and backwards, so as to leave the heart exposed; the heart is itself raised, and, as I have already said, the superficial cardiac region and the seat of the impulse are raised and extended upwards. The exposure of the heart is greatest on the affected side.

In emphysema, the right side of the heart is enlarged, but owing to the great expansion of the lungs, the superficial cardiac region and the seat of impulse are below the lower end of the sternum.

In cases of extensive pleuritic effusion, the heart is thrown over to the opposite side. If the effusion be into the left pleura, the heart, as it travels over, presents a different front, the left ventricle being the most anterior. At first the apex points behind the xiphoid cartilage, but as the fluid increases it moves over into the opposite side. If the effusion be into the right pleura, the heart moves over more and more to the left. As it does so the apex falls backwards, and the right auricle becomes the anterior portion of the heart, the left ventricle being quite out of sight.

When contraction of one side of the chest takes place in case of pleuro-pneumonia, after the absorption or removal of the fluid, the heart formerly pushed over to the sound side, is gradually drawn into the affected side, so that if the right side be contracted, the heart may beat to the right of the sternum, or if the left side be contracted it may beat to the left of the nipple. If the heart moves over into the right side of the chest the left ventricle is in front, if into the left side, the right auricle is in front. In these cases the right side of the heart is usually enlarged.

EFFECT OF DISEASES OF THE ABDOMEN ON THE POSITION OF THE HEART.

When the abdomen is excessively distended by intestinal distention, ascites or ovarian dropsy, the diaphragm is pushed upwards, and at the same time the heart and lungs are raised and compressed upwards.

When the stomach is excessively distended it more immediately elevates the heart, which is indeed situated just above the stomach. Hence one cause of the palpitation felt by dyspeptics after a flatulent meal.

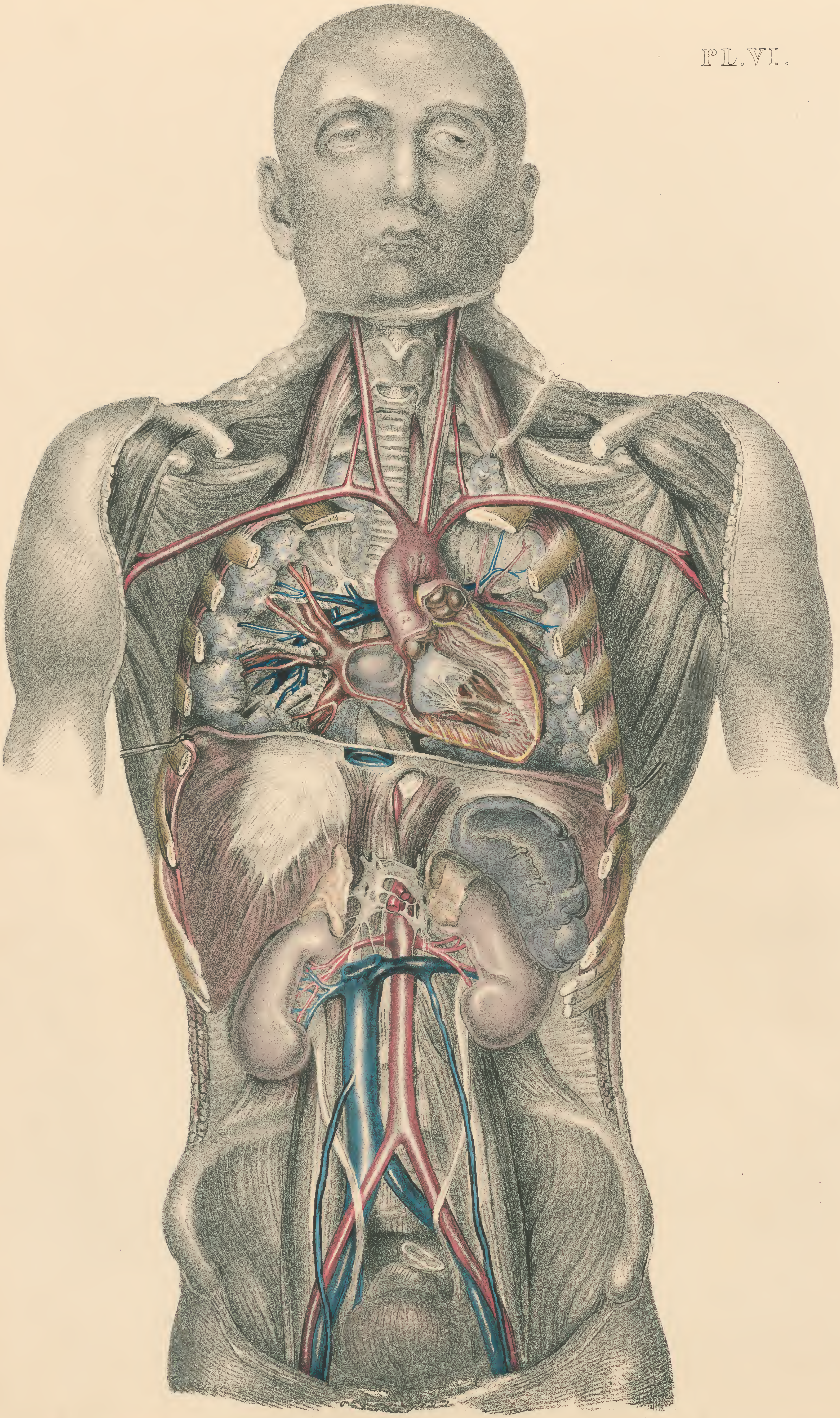
When the liver is enlarged from fatty degeneration or congestion, it tends rather to make its way downwards into the abdomen, than upwards into the chest. But if the right lobe of the liver be affected with malignant disease, an abscess, or a hydatid cyst, the diaphragm is raised, the right lung is encroached upon, and the heart is pushed upwards and to the left.

EXAMINATION OF THE HEART DURING LIFE.

The size, power, and condition of the heart in health and disease may be ascertained with more or less precision by observing the seat and force of the impulse, the extent of cardiac dulness on percussion, the amount of prominence over the region of the heart, the extent and character of the heart-sounds, the influence of respiration on the phenomena of the heart, the character of the pulse, and the condition of the veins in the neck.

The *impulse* gives the readiest and most certain sign of the presence of the heart. In health, the impulse of the apex may be felt in the fifth or fourth intercostal space, about an inch within the line of the nipple. In the robust, the impulse is often imperceptible, owing to the great extent to which the heart is covered by lung. When the impulse is present in the third and fourth intercostal spaces, and is followed by a sharp flapping diastolic impulse, felt over the second intercostal space, the heart is high and superficial, owing to the retraction of the lung, and the flattening of the sternum and cartilages.

PL. VI.



Drawn from the Subject and on Stone by William Fairland.

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When the impulse is felt in the sixth intercostal space to the left of the nipple line, the left ventricle is enlarged and thickened. When it is diffused over and to the left of the lower end of the sternum and xiphoid cartilage, the right ventricle is enlarged, probably from mitral regurgitation. When it is absent from the intercostal spaces, and is felt over, below, and to the left of the xiphoid cartilage, and with greater force during inspiration than expiration, there is probably emphysema with enlargement of the right ventricle. When the impulse of the apex is as low as the sixth intercostal space to the left of the line of the nipple, and that of the right ventricle is strong and heaving over the lower end of the sternum and the xiphoid cartilage, there is universal enlargement of the heart, probably from disease both of the aortic and mitral valves. When the impulse is strong and extensive, and is felt high up in the second interspace, as well as low down, and is but little lowered and lessened in extent by a deep inspiration, there is probably enlargement of the whole heart with universal adhesions.

When the impulse is absent, or very feeble, although the superficial cardiac region be extensive, the walls of the heart are weak or probably fatty: in this respect contrasting with those cases in which the impulse is absent because the lungs are large and are interposed between the heart and the walls of the chest, and in which the heart instead of being weaker is probably stronger than usual.

When the impulse is seated to the right of the sternum, there is probably either effusion into the left pleura, or contraction of the right side of the chest; and when it is felt unusually far to the left, the heart itself not being enlarged, there is, probably, either effusion into the right pleura, or contraction of the left side of the chest.

By *percussion* we can ascertain the boundaries of the superficial cardiac region with great precision. This does not hold good, however, with respect to the lower boundary, when the liver extends far to the left. A line drawn from below the seat of the apex beat, to the lower margin of the right lung, will then indicate the lower boundary of the heart.

Prominence over the region of the heart. In health the cartilages to the left of the lower end of the sternum are somewhat fuller than those to its right. When the heart is increased in size, especially in the young, the cartilages and ribs superficial to the heart are rendered unusually prominent.

The extent and character of the heart-sounds, when taken in connexion with the other signs and the symptoms, will generally enable us to detect whether the valves of the heart be healthy or diseased.

When there are no valve murmurs, we may generally infer that there is no valve disease. In some rare cases, however, the valve-murmurs cease as the valve disease advances, and sometimes also as the powers of the heart flag.

The aortic murmurs are louder in the direction of the current of blood, than they are directly over the aortic aperture itself, which is usually behind the centre of the sternum.

The aortic systolic murmur is usually the loudest in the neck, just over the innominata, above or to the right of the top of the sternum. Thence the morbid sound travels, with diminishing intensity, along the carotid and subclavian arteries. This murmur is feeble over the upper half of the sternum, if a thick layer of lung separates the aorta from that bone; but it is loud if that layer be thin, and louder still if the lung retract so completely that the sternum falls back upon the aorta. Under all circumstances the *bruit* is louder at the top than the middle of the sternum. The aortic systolic murmur is absent over the lower end of the sternum, unless it be musical and penetrating, so as to be heard over the whole body. This murmur is often audible over the upper dorsal vertebræ, whence it is gradually lost as we approach the seventh or eighth dorsal vertebræ. It may, however, when musical in character, be heard as low as the sacrum.

The diastolic aortic murmur being caused by regurgitation through the patent aortic aperture, is seldom heard over the great vessels in the neck, from which, instead of to which, it is conveyed by the current of blood. It is audible to the left of the apex, that being the direction of the reversed stream of blood; but it is usually loudest over the fourth, fifth, and sixth left costal cartilages. This can scarcely be explained on anatomical grounds, seeing that the right ventricle is interposed between the left ventricle and the aortic valves.

When the aortic diastolic murmur only lasts through the first half of the diastole, and the pulse expands and collapses visibly and rapidly, we may infer that the valves are altogether inadequate, and that the consequent regurgitation is great and rapid. If, however, that *bruit* be soft but loud, and prolonged through the whole diastole, the collapsing pulse being only slightly marked, we may infer that the aperture of regurgitation is but slight, and that the valves almost come together. When, under these circumstances, there is no systolic bruit, and the pulse is full and strong, we may infer that while the regurgitation is only slight, there is no narrowing of the aortic aperture. If, however, the pulse be small and feeble, while the systolic bruit is musical and prolonged, especially if a thrilling tremor be felt over the great arteries, we may infer that there is contraction of the aortic aperture as well as regurgitation.

When the heart is healthy the second sound of the pulmonary artery, which is inaudible over the neck, is merged in that of the aorta over the chest. When the aortic valves are insufficient the second sound of the pulmonary artery is still heard over the chest, though that of the aorta is absent, and the second sound is consequently inaudible over the neck.

The aortic second sound is sometimes very loud and ringing. This may be due to the aorta being atheromatous and dilated, or to hypertrophy of the left ventricle. If the second sound of the pulmonary artery be loud and ringing, it is usually a sign of active dilatation of the right ventricle, as in cases of mitral regurgitation or of emphysema.

Mitral regurgitation causes a systolic bruit that is loudest over, above, and to the left of the apex. It is also heard over the body of the heart, and it lessens in intensity as we approach its base. This murmur is often audible just below the angle of the left scapula, and behind the seventh and eighth dorsal vertebræ, whence it becomes more feeble as we ascend, thus differing from the aortic systolic murmur, which becomes feebler from above downwards.

In many cases of valve disease, the ringing noise made by the impulse of the heart upon the walls of the chest, tends to mask the valve murmur. This impulse noise is only heard over the superficial cardiac region. It is obliterated by the thinnest layer of lung. For this reason a mitral bellows murmur can be distinctly heard to the left of the nipple, when it is obscured by the impulse noise over the body of the heart. Singularly enough, the interposition of a slip of paper, or even the shirt of the patient, between the stethoscope and the skin, over the superficial cardiac region, obliterates the impulse noise. Should a mitral murmur be present, it is thus usually rendered much clearer, owing to the obscuring impulse noise being, so to speak, dissected away.

A mitral murmur is a proof of mitral regurgitation, but not of disease of the mitral valve; it having been noticed in cases in which *post mortem* examination revealed a healthy mitral valve.

The movements of respiration, as I have before stated, materially influence the size of the superficial cardiac region, the seat of the impulse, and the extent to which the heart's sounds are audible, since they are lowered and lessened in extent during inspiration, raised and enlarged in extent during expiration.

The character of the pulse, as I have just described, is an important sign in disease of the aortic valves. Aortic regurgitation is not the only cause of the visible pulse, since the opposite conditions of anæmia, and of active congestion of the brain, may equally give rise to visible pulsation of the carotid arteries. In the latter case, the character of the pulse is more bounding, in the former it is less collapsing, than in

EXPLANATION OF PLATE VI.

In the neck the anterior scalenus is removed.

In the chest, the right auricle and ventricle have been removed, exposing—the left auricle and ventricle, which are laid open, so as to show the mitral and aortic valves. The bronchial tubes, and the pulmonary arteries and veins, are shown in the right and partly in the left lung.

In the abdomen, the liver, stomach, and pancreas are removed, exposing—the diaphragm, the spleen, and the kidneys.

The solar plexus has been dissected upon another subject, and so to speak laid on upon this. The body, at this stage of the dissection, was not in a fit state for displaying the solar plexus.

In this and the following Plates the reduction has been effected by means of a pentagraph; in the previous Plate by the use of reduced squares. (Reduced from 32 inches to 19½ inches.)

cases of aortic regurgitation. When the arteries are atheromatous, they are both dilated and lengthened, and are therefore tortuous. These tortuous and prominent vessels do not pulsate visibly, but, having lost their elasticity, appear to be equally full during diastole and systole, unless there be also aortic regurgitation, when the pulse is remarkably visible, being alternately straight and tortuous.

The veins of the neck are not swollen in aortic disease, but they are so in many cases of enlargement of the right cavities, whether from mitral regurgitation, bronchitis, or any other cause inducing resistance to the pulmonary circulation. This is not so, however, in emphysema or phthisis, since in both those diseases the mass of blood is gradually lessened, so as to accommodate itself to the obstruction in the pulmonary circulation.

We ought not to decide rashly on the presence or absence of heart disease from the presence or absence of any single morbid phenomenon, however characteristic. By observing and combining all the signs and symptoms we can generally characterize, with an approach to precision, the nature of the disease. In some cases, however, even then, our diagnosis will be at fault. An accurate physical diagnosis is, however, in such instances practically of less importance than a just estimate of the vital phenomena, which will in fact always prove a better guide to treatment and prognosis than the mere observation of the signs, whether physical, chemical, or microscopical. These important signs indeed ought to direct our attention to the vital symptoms, and not to distract it from them.

THE ABDOMINAL ORGANS.

The abdominal organs vary greatly in position; they are all alternately displaced downwards by the inspiratory descent of the diaphragm, and replaced upwards by the expiratory action of the abdominal muscles. The stomach and intestines being sometimes empty, sometimes enormously distended, present in themselves the most extreme variety in size, form, and position; and they react upon the surrounding solid organs, which are pressed aside, and replaced, when the hollow viscera are distended, and emptied. The distention of the abdominal organs forces the diaphragm upwards, so as to contract the space occupied by the chest organs.

THE STOMACH.

The Stomach presents greater variety in size than any other organ in the body. In Plate I. it appears below the edge of the left lobe of the liver, while in Plate II. it is completely out of sight. Sometimes the stomach is so empty that it is like a mere piece of curved intestine, when the middle curve takes a vertical direction; while in the other extreme it is enormously distended, when the stomach takes more nearly a horizontal direction. Sometimes there is a distinct hour-glass contraction. Sometimes the pyloric half of the stomach is so contracted as to resemble a piece of intestine, as in Plates IV. and V.

It is usually the liver and not the stomach that occupies the so-called epigastric region or pit of the stomach just below the lower end of the sternum, as may be seen in Plates I. and II.: the cardiac orifice of the stomach is situated at the upper part of that region, immediately behind the liver and upon the diaphragm, Plate V. Thence the cardiac portion of the stomach turns off to the left at a right angle, so as to occupy and support the left hollow of the diaphragm, as may be seen in Plate I. and in the deeper view given in Plate V. If the stomach be empty or small, as in Plates II. and III., it only occupies a part, sometimes only a small part, of the left hollow of the diaphragm, which is then usually filled up and supported by the convolutions of the transverse arch of the colon, and of the small intestines, as in Plates II. and III. In this situation, the spleen is immediately behind the stomach; the shelving margin of the left lobe of the liver is immediately in front of it; and the lower sloping surface of the heart is just above it, resting upon the stomach as upon a floor. In fact, as may be seen in Plate V., the apex of the heart and the lower boundary of the right ventricle is above and just in front of the stomach, the convex upper portion of which is concealed by the shelving lower surface of the heart. This truly is the "cardiac" portion of the stomach. If pain be situated here in the stomach, it is generally referred to the heart. If the stomach be distended by a flatulent meal, palpitation and oppression in the region of the heart, often attended by dyspnœa, are the distressing sensations most complained of. In some persons, the resistance is so great to the return of blood from the head when the heart is compressed upwards

by the distended stomach, that sopor, coma, or an epileptic fit may be occasioned. A medical friend who died lately of disease in the brain, used to have an epileptiform fit whenever he ate pork. The heart and lungs are additionally and secondarily affected by the influence of the swollen stomach upon the liver. That organ being compressed upwards and to the right by the stomach, in turn compresses upwards the heart and the right lung. Under the same influence a considerable portion of blood is pressed out of the liver through the hepatic vena cava, into the right auricle, which is thereby distended with blood. In addition to all these serious effects of extreme distention of the stomach, the whole diaphragm is raised and its inspiratory descent is impeded. The lungs are consequently compressed upwards into the chest, diaphragmated respiration is difficult, thoracic respiration is laborious, the veins of the neck and forehead become swollen, the face is flushed, and the brain is congested.

In gastralgia the pain is generally referred, not to the stomach but to the heart, and it is often attended by palpitation and intermission of pulse. The patient indeed, in dyspepsia, is often convinced that he labours under affection of the heart.

If we percuss over the stomach when the patient lies on the back, the sound elicited is resonant, but when he stands, it is usually dull. This is owing to the gravitation of the food.

THE LIVER.

The variation in size and position of the liver is very great. In Plate I., the lower edge of the liver is only two or three inches above the umbilicus, while in Plate II., a small portion only of the organ is seen below the xiphoid cartilage. In Plate I., from a robust man, the lungs are large, and the diaphragm and liver are unusually low, their summit being behind the fifth right rib; while in Plate II. from a slender youth, the lungs are contracted, and the diaphragm and liver are rather higher, their summit being behind the fourth right rib. (Plate IV.)

Again, in Plate I., the intestines are not nearly so much distended with flatus as in Plate II. Consequently, in the latter, the liver is displaced upwards by intestinal distention more than in the former.

These two causes, the greater or less descent of the diaphragm, and the greater or less distention of the stomach and intestines, give rise to all the remarkable varieties in position and size of the liver.

During inspiration the whole liver is lowered, and its convexity is flattened by the descent of the diaphragm. An additional quantity of blood is thereby pressed into the right auricle, at the very time that the lungs as well as the heart, owing to the expansion of the chest, are capable of holding more blood. During expiration, on the other hand, the chest is contracted, and the right cavities being compressed, the blood accumulates in the liver and the veins of the neck.

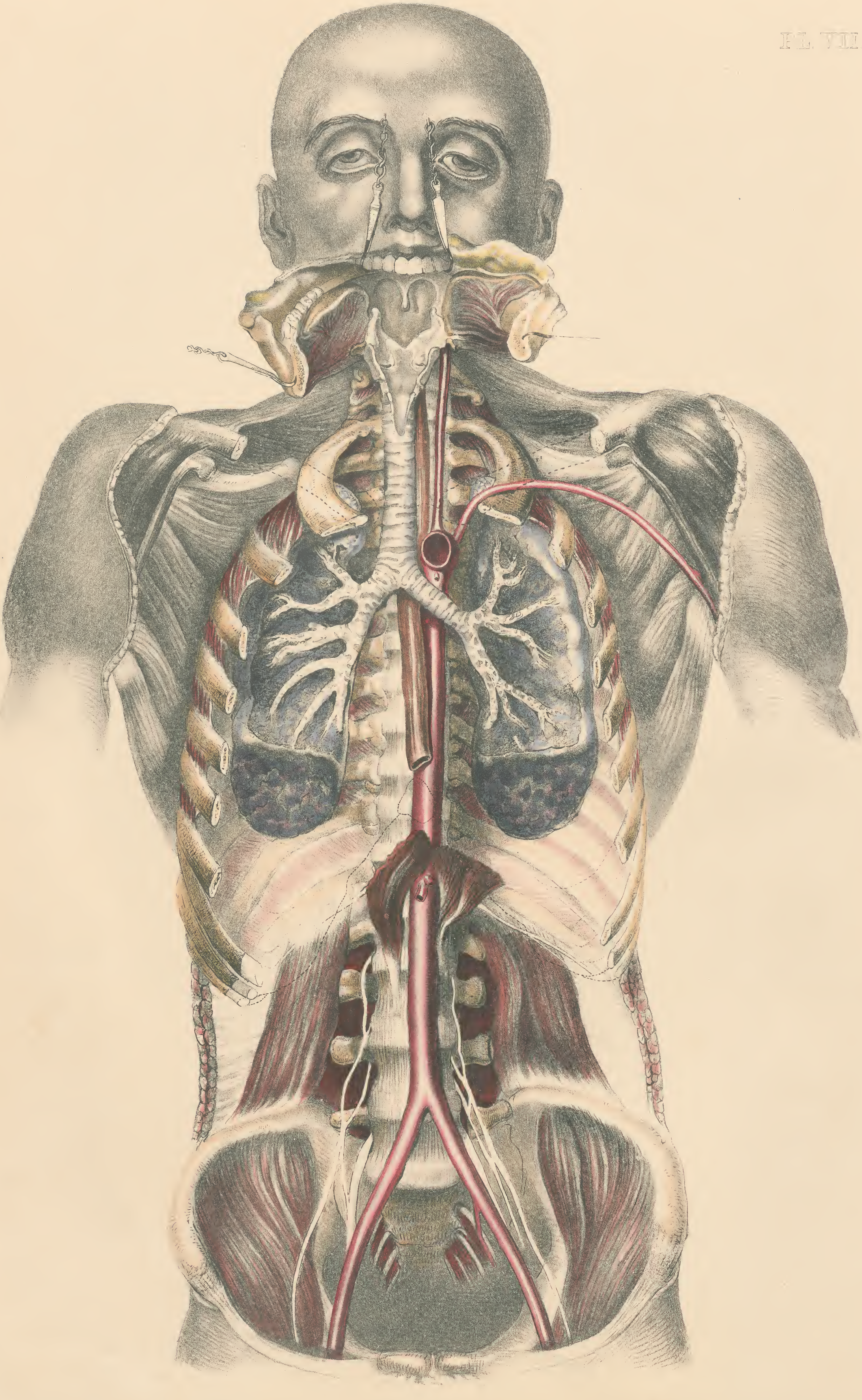
The play of respiration, whereby the liver and spleen, and to a less degree the kidneys, are subjected to alternate compression and expansion, and the stomach and intestines to a perpetual churning motion, has an important physiological action on the functions of those organs. Hence no doubt one of the reasons for the important influence of exercise on digestion and the action of the liver and kidneys.

The variety in position of the liver is still greater than that exhibited in Plates I. and II. I examined recently the body of a patient who died of a fever, in which the liver was so far displaced upwards by the swollen intestines, that its lower margin was hidden by the lower edge of the right lung; and I figured in the Prov. Med. Trans. vol. xii., the body of a female who died of inanition owing to malignant disease of the œsophagus, in which the stomach and intestines were empty, and the liver covered the greater part of the abdomen, its lower margin resting on the crests of the ilium.

When the stomach is empty, the left edge of the liver tends over to the left side of the abdomen; when the stomach is distended, it pushes the liver unusually to the left and somewhat upwards. When the great and small intestines are empty, the liver falls downwards into the abdomen; and when they are distended, it is pushed directly upwards.

In emphysema, owing to the low position of the diaphragm, the liver is unusually low, and in phthisis and the bed-ridden, in consequence of the high position of the diaphragm, the liver is unusually high. Hence the position of the lower edge of the liver in the abdomen is not, in itself, a guide to the size of the liver.

I shall return to the consideration of the subject of the abdominal organs in a future commentary.



COMMENTARY ON PLATE VII.

THE LARYNX, TRACHEA, BRONCHI, AND LUNGS.

In Plate VII. a section is made through the centre of the jaw, the tongue, the epiglottis and the front of the larynx, so as to expose the fauces, pharynx, and interior of the larynx.

The epiglottis stands erect upon the thyroid cartilage behind the base of the tongue, so as to form in part the permanently open channel through which the respired air passes from the nostrils into the larynx; and to aid, by its elasticity, in keeping that channel open.

During the act of swallowing, the larynx is drawn forcibly forwards and upwards, so as to be covered by the back of the tongue, the pharynx being at the same time distended, so as to occupy the space previously taken up by the larynx.

It has been the fashion of late, with some, to sponge the larynx with a strong caustic solution in cases of laryngitis, croup, hooping cough, and other chest affections. This procedure is of use in some cases of croup and of chronic laryngitis, but in acute laryngitis it is sometimes mischievous, and in phthisis and bronchitis it is irrational. I have now under my care, in St. Mary's Hospital, a man suffering from laryngitis. His larynx had been mopped out thrice in the course of ten days, with the effect, on each occasion, of aggravating the disease; nothing else was done until he declined a fourth application. Dr. Green has wisely advised that the fauces should be washed over with a solution of nitrate of silver, two or three times before it is applied to the larynx.

When the solution is applied to the larynx, the bent probang, armed with a sponge saturated with the solution, ought to be passed behind the epiglottis, and then pressed steadily forwards and downwards, gliding it along the posterior surface of the epiglottis.

It is perfectly easy to pass a male catheter into the larynx in this way, when, owing to laryngitis or other such cause, laryngotomy is demanded. The insertion of the catheter, by admitting air, gives time for the performance of the more important operation, and it may sometimes enable it to be dispensed with.

In performing laryngotomy, I advise that the tissues between the thyroid and cricoid cartilages be divided quite down to, but not through the mucous membrane; which ought to be transfixed carefully by the bent trochar and canula, the point of the trochar bearing not backwards but downwards. This plan obviates the danger of transfixing the back of the larynx, which is liable to occur in the child, when the trochar is thrust through the thick membrane; as well as the danger of hæmorrhage into the larynx, since the canula fills up the aperture.

When artificial respiration has to be sustained for a long period, I advise that the apparatus be adjusted to the canula, inserted, by the operation just described, into the larynx. Dr. Marcet's apparatus for artificial respiration, which alternately exhausts and expands the lungs, appears to me to be well adapted for its purpose. It certainly obviates the danger of rupturing the air-cells, which is apt to occur when the bellows are employed, and I think it better than the graduated syringe with Mr. Jackson's double action tap, which I recommended some years since as being more accurate than, and therefore preferable to, the bellows.

The signs of laryngitis, derived from anatomical considerations, are noisy, hissing, or stridulous respiration, audible at a distance from the patient, and louder during expiration; the same noise over the larynx and trachea, with absence of the respiratory murmur over the lungs; alteration or loss of voice; imperfect husky character of cough, which is never clear and ringing; frequent but vain efforts to clear the larynx; diminished movement or retraction of the walls of the chest during inspiration; and as the disease advances, especially in the adult, pain, and sense of suffocation when swallowing. The pain is caused by the pressure of the food against the arytenoid cartilages; the sense of suffocation, by the suspension of breathing, induced by the act of swallowing, and the impossibility of increasing the supply of air, already too scanty, so as to make up for the suspended breathing. Indeed the act of drinking, owing to this suspension of respiration, excites in all persons deep and hurried, often sobbing inspiration.

When there is œdema of the glottis, the edge of the epiglottis, instead of being thin and flexible, is round and tense, as may be ascertained by passing the finger over the back of the tongue. Under such circumstances the free scarification of the epiglottis sometimes gives relief.

Croup is distinguished from laryngitis by the ringing cough, the more stridulous breathing, the presence of the voice, and the power to cry.

Pharyngitis is distinguished by the predominance of dysphagia over dyspnœa, and by the pain excited by pressure of the larynx backwards.

Abscess between the larynx and pharynx may be detected by the absence of the usual crepitation when the larynx is moved from side to side, as well as by the local swelling and fluctuation.

Affection of the recurrents, caused by the pressure of aneurismal or other tumours, is to be distinguished from laryngeal disease by the existence of the tumour causing the affection; and by the absent or altered voice, and the imperfect hoarse cough, being more marked than the difficulty of breathing, and the hissing or stridulous character of the breath sound.

In cases of aneurism of the arch of the aorta, dyspnœa is induced, and blowing respiration is heard between the scapulæ, owing to the pressure of the aneurism on the trachea at its bifurcation, the left bronchus being more involved than the right. This effect is often lessened when the patient bends forward, so as to relieve the trachea and bronchi from the pressure of the tumour.

The same effect is induced by excessive distension of the pericardium with fluid; the dyspnœa excited by the pressure of the fluid backwards upon the trachea being greatly relieved when the patient leans forward.

The voice originates in the vocal chords. The vocal vibrations, thus originating in the larynx, would be feeble, and only audible at a short distance, were it not that they are reinforced by the consonating vibrations which are excited in the cartilages of the larynx, trachea, and bronchi, the walls of the chest, the nasal cartilages, and the cranium. In the same way, the tuning fork, when struck and held in the air, excites a feeble, scarcely audible, sound, but when it touches a table, the sound is heard over the whole room, owing to the note being propagated from the fork to the entire table, the vibration of which

EXPLANATION OF PLATE VII.

From the same subject as Plates II., III., IV., V. and VI.

In the head and neck, a section has been made through the jaw, the tongue, and the front of the larynx, exposing the fauces, pharynx and interior of the larynx.

In the thorax, the heart, the arch of the aorta, the anterior portion of both lungs, and the pulmonary vessels have been removed, exposing—the bifurcation of the trachea, and the ramifications of the bronchi; and the lungs, aorta, and æsophagus in relation to the vertebræ and ribs.

In the abdomen, the spleen, the kidneys, and the diaphragm, have been removed, exposing—the aorta in relation to the vertebræ. (Reduced from 32 inches to 21 inches.)

may be felt by the hand. In like manner, when a person speaks, the vocal vibrations excited in the chest may be felt by the hand, and the vocal resonance may be heard by applying the ear to the chest.

The vocal vibrations and resonance are present wherever there is lung, but they are absent over the ribs superficial to the heart, the liver, and the stomach. The distribution, therefore, of the vocal vibrations is purely anatomical, and their presence or absence indicates to us the presence or absence of lung at any particular part of the costal walls. When we take a deep breath, the lungs expand downwards a full inch, and the vocal vibrations expand downwards to the same extent. The vocal vibrations are strong where the volume of the lung is large, feeble where it is small. Thus the vibrations are strong over the right mammary region, feeble when the lung overlaps either the heart or the liver.

When from pneumonia, tubercular infiltration, or pulmonary apoplexy, the tissue of the lung becomes solid, while the bronchi are themselves free, the vocal vibrations are rendered stronger. If, however, under these circumstances the tubes are themselves blocked up, the vocal vibrations become feeble or disappear. As Skoda has advanced, the smaller bronchi, being devoid of cartilage, scarcely consonate in health; though they consonate freely when their walls are rendered solid, and therefore capable of vibrating, by the presence of the surrounding exudation in the air cells. The vibrations then excited are stronger or weaker in proportion as the exudation, surrounding the tubes, is more or less dense and universal. Thus the vibrations are stronger in pneumonia than in phthisis.

When the lungs are separated by pleuritic effusion from the walls of the chest, the vocal vibrations are no longer perceptible. In such cases the lung floats forward, the fluid gravitates backward. When the patient lies on the back, the vibrations are present in front while they are absent behind; whereas, when he lies on the face, owing to the interchange of position of the effused fluid and the lung, the vibrations are present over the dorsum, absent over the front of the chest.

A loud smooth breath-sound is heard over the larynx and trachea, during respiration. This is equally loud during expiration and inspiration. This sound is caused by the play of the current of respired air over the glottis.

Contrary to Laennec and Skoda, I hold that the respiratory murmur, like the vocal resonance, originates in the larynx, and is conveyed thence during inspiration by the current of air, the sound being somewhat reinforced by consonance in the tubes themselves. If the respiratory murmur originated in the air cells and smaller bronchi, it would necessarily be loudest, where the respiratory expansion of the lungs is most abundant and most active. Now this is quite contrary to the fact. In the adult male, the inspiratory murmur is very feeble, and the expiratory murmur is scarcely audible over the lower part of the dorsum, although at that part the mass of the lung is greater, and its expansion more active than elsewhere. On the other hand, over the upper part of the chest the inspiratory sound is loud and the expiratory sound is quite audible, and yet the volume of the lung is there comparatively small and the costal expansion slight. Indeed at that very part, the expansion of the lung, in tranquil breathing, is mainly due to the descent of the diaphragm, which, in fact, expands the whole lung, from base to apex.

The fact is, that the inspiratory murmur is louder, and the expiratory murmur is more audible, the nearer the portion of lung examined is to the larynx. The smaller the lung the louder the murmur; thus it is louder in the female than the male, louder in the child than either. I regret that I have not space to argue out the whole question.

When the lung is consolidated by exudation, or condensed by the pressure of fluid, or any other cause, the expiratory breath-sound, in health so faint, or even imperceptible, becomes developed in a very remarkable manner, provided the bronchi are pervious. In pneumonia the expiratory sound is blowing, tubular, and metallic. In pleuritis, with slight effusion, the same sound is often heard over that part of the condensed lung which, being just above the fluid, is in contact with the walls of the chest. The region over which tubular breathing is heard in pleuritis, shifts with the change of position, and the consequent gravitation of the fluid. When there is complete tubercular infiltration, the tubular breathing is nearly as blowing and metallic as in pneumonia, provided the tubes are not occupied by mucus, as they often are, owing to the softening of some part of the affected tissue. When tubercles are scattered, with, perhaps, here and there small interspersed patches of tubercular pneumonia, the expiratory breath-

sound does not present the tubular character of pneumonia, but it is much louder and more audible than in health.

In many cases of tuberculous disease, and of pleuritis with effusion, bronchial expiration is absent during tranquil breathing; but it becomes quite palpable and characteristic when the patient whispers, and so increases the energy of the expiration. In all cases of real or suspected chest affection, I am in the habit of desiring the patient to whisper, while I listen, first over the suspected, and then over the corresponding healthy region.

I am convinced that Skoda is right in attributing this altered and augmented expiratory breath-sound to consonance in the walls of those open tubes, surrounded by solid lung tissue.

The phenomena of Bronchophony, Pertoriloquy, and Ægophony, are not due to the vocal resonance alone, but to the combination of the tubular breathing with the vocal resonance. Whenever either of these phenomena is present, if we desire the patient to whisper, we hear the tubular expiration penetrating the ear with each whisper. If we now desire him to speak, we may notice that the vocal resonance is accompanied and modified in character by the whisper. We may notice also that, towards the end of each word, a short jet of whispering follows after the cessation of the vocal resonance.

I thus explain the difference between Broncophony and Ægophony. In broncophony from pneumonia, the vocal vibrations are unusually strong; in ægophony from pleuritic effusion, the vocal vibrations are unusually weak. Hence, the bleating character in ægophony—the whisper, as it were, almost drowning the voice, and hence, the bronchophonic character in pneumonia, the voice almost drowning the whisper. In each, however, the whisper and the voice combine to produce the characteristic effect, the one accompanying the other, like the drone and the tone of the bagpipe.

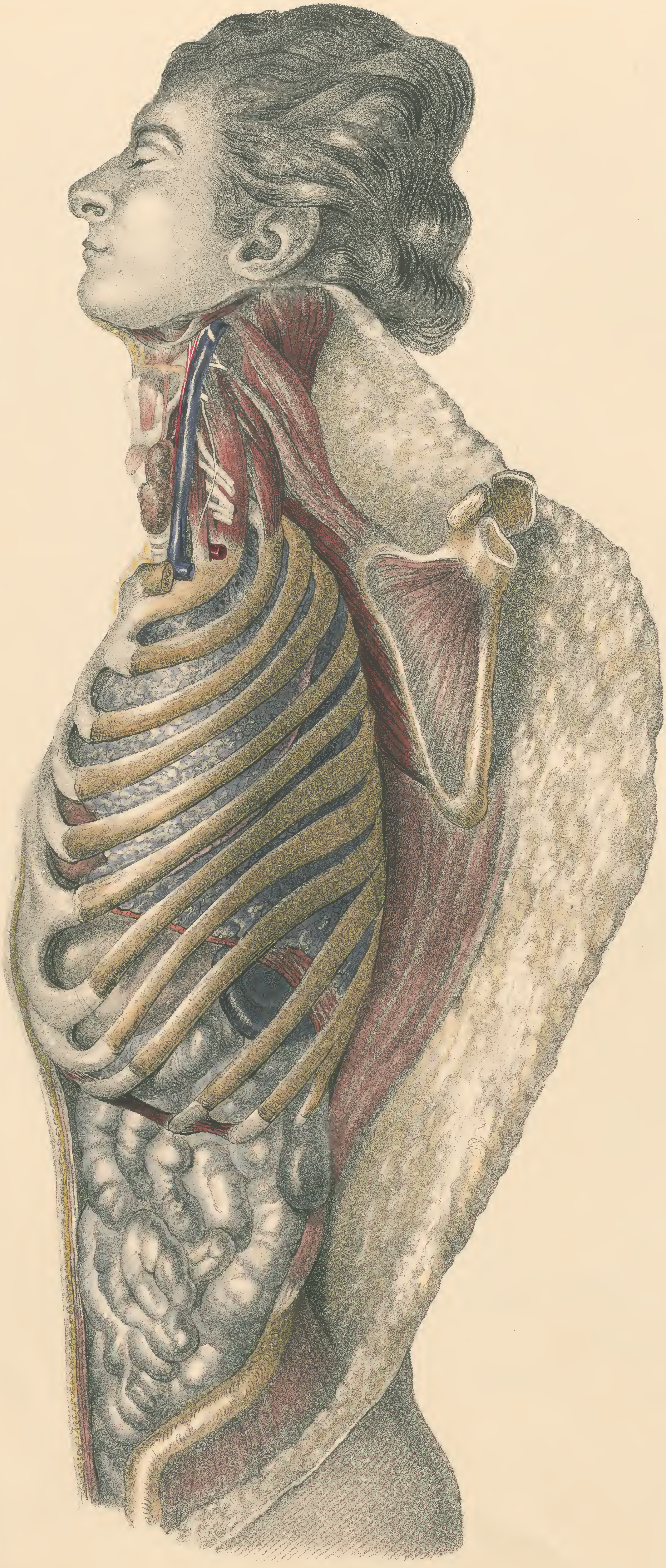
The trachea, in its descent, bears to the right, being, at its bifurcation, in front of the right half of the bodies of the fifth and sixth dorsal vertebræ, while the aorta, alongside of it, is in front of their left half. (See Plates V. VI. VII.) The breath-sounds are consequently louder over the right than the left edge of the sternum, from its summit to the third costal cartilages.

The right bronchus plunges at once into the right lung, the bronchi curving upwards to the upper, outwards to the middle, and downwards to the lower lobe. The left bronchus takes a long course downwards and outwards in front of the œsophagus and through the arch of the aorta. The left bronchus consequently enters the left lung, and breaks up into its divisions, much lower down than the right bronchus. The bronchus leading to the summit of the left upper lobe turns directly upwards, being much longer than that to the right upper lobe. The bronchus to the lower portion of the left upper lobe passes directly outwards, corresponding thus to the right middle bronchus.

The result of this anatomical arrangement is, that the healthy breath-sounds are louder, and the vocal vibrations are stronger, over the right than the left upper lobe, both above and below the clavicle and above the scapula. When, therefore, the breath-sounds, expiratory as well as inspiratory, are louder, and the vocal vibrations are stronger over the right than the left upper lobe, there is no ground, from these signs, to infer disease of either lobe. If, however, the inspiratory sound is more feeble, and the expiratory sound stronger on the right than the left upper lobe, while the heart's sounds are louder, the chest flatter, and the stroke on percussion somewhat less resonant on that side, we have grounds for suspecting condensation of the right upper lobe. If we find that the vocal vibrations are stronger and the breath-sounds are louder, especially during expiration, over the left than the right upper lobe, our suspicions must then be turned to the left side.

The descending vena cava occupies a much larger space to the right of the aorta than the pulmonary artery does to its left; since, while the pulmonary artery disappears behind the arch, the vena cava extends from the top of the sternum downwards. The right lung is consequently more encroached upon by the vena cava than the left lung by the pulmonary artery. The result is, that the percussion stroke is more resonant to the left than the right of the upper portion of the sternum. This is more appreciable when the chest is flat and the lungs are small, as in the bed-ridden and the feeble, than when the chest is full and the lungs are large, as in the robust, and in those affected with emphysema. We must, therefore, be careful not to condemn the right upper lobe, merely because the percussion stroke is more dull to the right than to the left of the upper portion of the sternum.

PL. VIII.



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COMMENTARY ON PLATES VIII. & IX.

THE RIBS, DIAPHRAGM, LEFT LUNG, HEART AND GREAT VESSELS.

THE RIBS.

See Columns 1, 2, 3.

It may be observed in Plate VIII., which represents a side view, that the sixth and seventh ribs present themselves to each other, like two bent bows set back to back. The sixth rib has along the upper margin a concave edge looking upwards, while the seventh rib has along its lower margin a concave edge looking downwards. Every rib above the sixth presents, like it, a concave edge looking upwards. The eighth and ninth ribs, like the seventh, are bent downwards. Owing to this arrangement the ribs from the sixth to the ninth are crowded together, the intercostal spaces being very narrow.

During a deep inspiration, the upper ribs converge, while the lower ribs diverge, and all the ribs become parallel to each other.

THE DIAPHRAGM.

See Column 12.

In Plate VIII., as in Plate I., I have cut away the diaphragm, all but a thin strip which is seen through the intercostal spaces, just below the margin of the lung. By this plan the stomach, spleen, kidney, and intestines, can be seen in their relative position through the intercostal spaces. The diaphragm, which can be readily replaced by the mind's eye in these views, is left entire in Plate II. Its left arch and central tendon are shown in a side view in Plate IX., and the upper and under surfaces of both arches are exhibited in front views in Plates IV., V., and VI.

The mind naturally associates the chest with the ribs, the abdomen with the whole space below the ribs. In reality, however, the more important of the abdominal organs, as can be seen in the plates referred to, are shielded by the ribs from pressure and external violence. The diaphragm in its descent during a deep inspiration, while it expands the lungs downwards, pushes before it the whole of the abdominal organs, so that the liver, stomach, spleen, and kidneys are no longer protected by the lower ribs. Indeed, during a deep inspiration, the lower portion of the right lung and heart are drawn downwards so far in front, by the diaphragm, as to be seated below the xiphoid cartilage. During inspiration, therefore, the cavity of the chest encroaches downwards upon the abdomen; while during expiration the cavity of the abdomen encroaches upwards on the chest. In the robust, as in Plate I., especially when they are in constant exercise, the diaphragm is habitually low; while in the feeble, and still more in the bed-ridden, it is unusually high, so that the heart and lungs are crowded upwards into the chest—being encroached upon by the abdominal organs.

After a full meal, the distended stomach makes way for itself in every direction, so that, while it displaces the other abdominal organs downwards, it raises the diaphragm and thus encroaches upon the heart and the left lung. (See above, at column 23.)

THE LEFT LUNG.

See Columns 3—10, 26—28.

The complete bearing of the upper lobe of the left lung to the lower lobe, can only be appreciated by the examination of the side view. The left upper lobe is really the anterior lobe. When the chest is looked at in front, the upper conceals nearly the whole of the lower lobe from view, a small portion only of that lobe coming into sight at the outer and lower part of the chest. (See Plates I., II., III.) In like manner the lower is really the posterior lobe, since if we examine the chest from behind, the lower lobe appears to occupy nearly the whole chest, only a small cap of the upper lobe appearing above the lower, the septum being generally in front of the third rib.

When we look at the side view, we at once see how the upper lobe laps over and lies obliquely in front of the lower. The upper lobe occupies the upper and anterior, the lower lobe the lower and posterior part of the chest, the septum between them running obliquely from behind forwards and downwards. In Plate VIII. the septum begins behind and above, at the third intercostal space or fourth rib, crosses, as it works towards the front, the fourth and fifth intercostal spaces, and appears finally in the sixth interspace, along which it passes forward, parallel to the lower edge of the sixth rib, behind which rib it disappears, to end in the base of the lung, near the apex of the heart. Usually the septum is a rib's breadth higher in situation, beginning above and behind at the third, instead of the fourth rib, passing along the fifth, instead of the sixth intercostal space, and disappearing behind the sixth rib, as in Plates I. and II.

The septum moves downwards during inspiration, upwards during expiration; the upper lobe as well as the lower, being expanded downwards by the descent of the diaphragm, the movements of which act upon the whole lung from base to apex.

When the whole of the lower lobe is affected with pneumonia, the line of the septum forms the exact boundary of the disease. Behind that line we find dulness on percussion, blowing respiration, and increased vocal vibrations; in front of it, resonance on percussion, the respiratory murmur, and normal vocal vibrations. Whether the patient lie on his back, his face, or his side, or sit up, the seat of the affected lobe is the same, and the anterior boundary line of the region of dulness on percussion and of exaggerated vocal vibration is unchanged. When the whole lower lobe is the seat of pneumonia, the exudation distends the air-cells, and the entire lobe is enlarged to the same extent as during a deep inspiration, the base of the lung being lower than usual by one inch. While the lower lobe is distended by the exudation of pneumonia, the upper lobe is expanded almost to its full extent by inspired air, to compensate for its deficiency in the lower lobe, and the position of the septum is lowered.

When the whole of the upper lobe is the seat of pneumonia, or of tubercular infiltration, we find the region of dulness on percussion, increased vocal vibration, and bronchial breathing, limited behind by the line of the septum. In front of, and above that line, we discover the abnormal signs; below and behind it, the normal signs. In this case, as well as in pneumonia of the lower lobe, the septum is lowered. But in this case, while the upper lobe is enlarged, owing to the distension of its air-cells with exudation, the lower lobe is expanded to its full extent by inspired air, so as to compensate for the deficient breathing above, and the base of the lung is lowered.

EXPLANATION OF PLATE VIII.

This Plate and Plate IX. represent views of the left side, the body lying upon the back. They were taken from a tall, robust man, aged thirty-eight.

When the outlines of the intestines were taken, those in front of the lumbar region were retained *in situ* by the lumbar fascia; but when the fascia was cut away, the intestines gravitated backwards, and were no longer *in situ*. An imaginary representation has consequently been given of those intestines seated behind a horizontal line running from the tenth costal cartilage to the ilium.

In this view the ribs are left, the intercostal muscles and the diaphragm being removed. Thus the lungs and heart, and the stomach, colon, and spleen, and the upper end of the kidney, are seen in their relative position, through the intercostal spaces.

In this Plate the inferior margin of the lower lobe is represented as coming down too far posteriorly. The lower lobe was affected with pleuropneumonia in this body, and was thus rendered very distinct from the upper lobe.

(Reduced from 36 inches to 21.)

I have observed in several cases of pneumonia of the upper lobe, a marked limitation of the disease to that portion of the lobe which is above the third rib. The line of demarcation was abrupt. All above that line, I found absolute dulness on percussion, intense tubular breathing and exaggerated vocal vibration; or at an earlier stage coarse crepitation: all below that line, the resonance, the breath-sounds, and the vocal vibrations were normal. This tendency to limitation is manifestly due to the mode of the distribution of the bronchi, arteries and veins to the region indicated. In phthisis, the disease tends to limit itself in a like manner, but, owing to the exudation being scattered, and being interspersed with sound lung, it is not so marked as in pneumonia. In two cases of pneumonia of the upper left lobe, this limitation was not present, the whole of that lobe being affected.

Pneumonia of the upper lobe may usually be readily distinguished from phthisis by signs based upon anatomical grounds. In *pneumonia* the upper part of the chest is rather fuller than usual, the nipple being generally superficial to the fifth rib; in the early stage, the crepitating rhonchus is heard over the whole of the affected region, being limited thereto; in the more advanced stage, the dulness on percussion, tubular breathing and increased vocal vibration, are all of a decided character, and the contrast between the healthy and the diseased portion of lung is complete. In *phthisis* the chest is flattened below the clavicle, the nipple being superficial to the fourth rib; the crackling rhonchus, if present, is neither equally diffused nor precisely limited; the dulness on percussion, the bronchial breathing and the increased vocal vibration, though present, are not of so decided a character as in pneumonia; and the morbid signs, instead of giving place abruptly to the normal signs, below the limits of the disease, pass off by imperceptible shades from the one into the other. The abrupt limitation of pneumonia behind, both as regards the exudation and the signs, is seated along the line of the spine of the scapula, which corresponds to the septum between the upper and lower lobe.

That portion of the left upper lobe, which forms the upper and left margins of the frame of lung in which the heart is set, and which presents, just over the apex, the peculiar tongue of lung, seen in Plates III. and VIII., is not usually affected with phthisis until the later stages, when it usually presents itself, not in the form of scattered tubercle, but of tuberculous hepatization. If coarse crepitation, or tubular breathing, is heard just to the left of the apex-beat, and if the region in front of the fifth rib, corresponding to the upper lobe, is dull on percussion, while that behind and below the fifth rib corresponding to the lower lobe is resonant, the disease is probably advanced phthisis. The history of the case, as well as the physical signs, will readily enable us to decide whether the disease be phthisis or pneumonia of the whole upper lobe.

That part of the upper lobe which is situated above the clavicle, and which, when looked at from the front, seems to occupy a part of the neck, is represented in front in Plates I. and V., and at the side in Plates VIII. and IX. By examining the side views, it will be at once seen that owing to the sternum being raised during inspiration, a smaller portion of the lung then appears above the clavicle than in expiration.

In the robust, as in Plate I., and still more in those affected with bronchitis, the extent to which the lung appears above the clavicle is much less than in flat-chested persons, and in those affected with phthisis. In the robust, the lungs are more as they are during inspiration; in the slender, they are more as they are during expiration. In general, the summit of the upper lobe is about one inch higher than the clavicle. The subclavian artery, on either side passes over the front of the lung, from half an inch to one-third of an inch below the apex. (Compare Plates I., V., and IX. with each other.)

The right subclavian arises from the arteria innominata, just in front of the right edge of the trachea (see Plates V. and IX.), while the left subclavian originates from the aorta itself deep down in the chest, just in front of the head of the fourth rib. (See Plates IX. and V.) At its origin, and in its course (see Plate IX.), the left subclavian is on a level with the posterior edge of the trachea, and is therefore much deeper than the right subclavian, which, as we have just seen, crosses the front of the trachea. As the left subclavian ascends, it is half embedded in the lung, and, owing to its long course and its deep position compared with the right subclavian, the left upper lobe, above the sternum, is both narrower and shallower than the right upper lobe. The result is, that in health the percussion-stroke

is, above the clavicle, somewhat less resonant over the left than the right upper lobe. The breath-sounds and the vocal vibrations are also more feeble over the left summit, on account both of this anatomical arrangement, and of the much greater length of the left than the right upper bronchus. (See Plates VII. and IX.)

In Plates IX. and VII. the head of the third rib is just above the level of the top of the sternum. The third rib is in front of the spine of the scapula; and as that rib corresponds to the septum between the upper and lower lobe at the back, the spine of the scapula forms the recognizable boundary behind, between the upper and lower lobes. When the summit of the upper lobe is affected with pneumonia, the morbid signs over the upper lobe are exactly divided from the normal signs over the lower lobe by the spine of the scapula. It is just the reverse when the upper part of the lower lobe is affected with pneumonia. In that case, below the spine of the scapula we have the morbid signs, above it the normal signs; whereas, in the former case, above the spine we find the morbid, below it the normal signs.

In phthisis the disease is usually seated above the spine of the scapula, but, as I have already remarked, the line of demarcation between diseased and healthy lung is by no means so abrupt as in pneumonia.

In pleuritis, the inflamed surfaces are, just at the onset, in contact with each other, and *frottement* is then sometimes audible. The increasing pleuritic effusion, however, speedily separates those surfaces from each other, and to a gradually increasing extent. In most cases, therefore, *frottement* is absent during the early and advancing steps of the disease. During this period, the effusion when the patient lies on his back gravitates to the posterior portion of the chest, forming a horizontal line of fluid, which becomes gradually thinner towards its anterior edge. Behind this line, we find dulness on percussion, and absence of the respiratory murmur and of vocal vibrations; in front of this line, we have resonance on percussion, loud respiratory murmur, and strong vocal vibrations. The abnormal and the normal signs shade gradually off into each other. Just over and adjoining the anterior margin of the fluid we have, generally, bronchial breathing, and with it œgophony. If the patient turns over on the face, the fluid, yielding to the force of gravity, sinks towards the facial aspect of the chest, the lung floating to its dorsal aspect. The abnormal signs are now heard over the front, the normal signs over the back of the chest.

If the patient sits up, the horizontal line of the gravitating fluid completely changes its direction, and traverses the chest horizontally instead of vertically. The abnormal signs now occupy the lower, the normal signs the upper part of the chest, and the bronchial breathing and œgophony, if present, encircle the affected side, over the edge of the fluid.

If the fluid becomes excessive, it compresses the lung more and more, and pushes aside the neighbouring organs. The heart is displaced to the right of the sternum, and the diaphragm, and with it the stomach, the adjoining intestine and the spleen are pushed downwards and to the right, so as to be entirely below the lower edge of the ribs.

As the effusion disappears, all these organs gradually regain their normal position, and the lung and the diaphragm come again to a greater and greater extent in contact with the ribs.

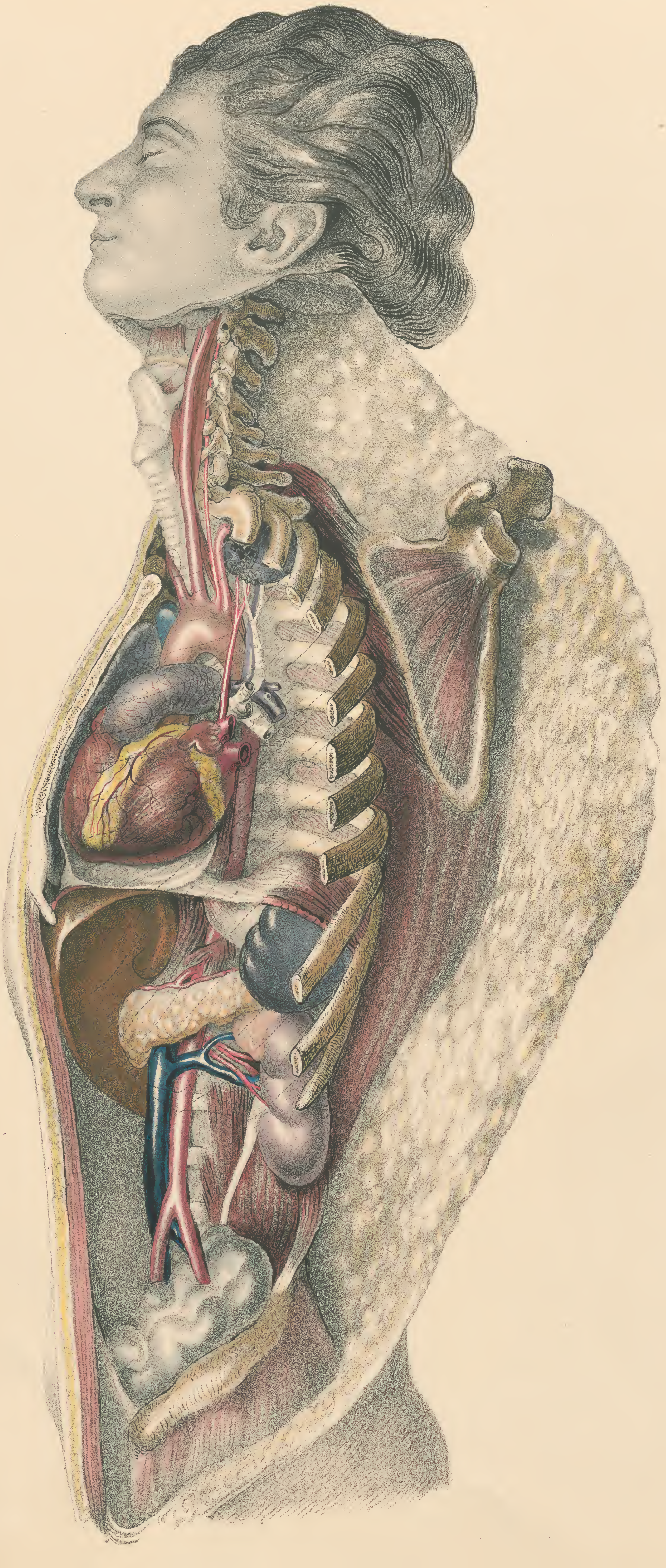
At this stage, the friction-sounds, so long absent, come into play, being generally first audible over a space two or three inches square, just below the heart, over the sixth and seventh costal cartilages. As the fluid diminishes, the extent to which the friction-sounds are audible increases gradually towards the left side. The anatomical position of the *frottement* at this stage is in fact, not over the lung but over the diaphragm, the movements of which bear with greater rubbing force on the ribs than the movement of the lungs. At length, however, the friction-sound extends upwards over the lung itself, the area of *frottement* corresponding to the area over which the costal and pulmonic pleuræ are roughened by the new membrane.

With the increase in the area of the friction-sound there is generally an increase in its loudness and harshness. The extent and harshness of the *frottement* thus increasing as the disease itself diminishes.

The friction-sound ceases to be audible when and where adhesions take place.

I have now under my care in St. Mary's Hospital, a young woman who was admitted seven weeks since, with extensive pleuritic effusion.

PL. IX.



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The heart was beating to the right of the sternum; the whole of the left side was dull on percussion; the face was dusky, the respiration excessively hurried. The veins of the neck, especially the left jugular, were swollen, even during inspiration. The obstruction to respiration and to the circulation through the lungs was so great, and the danger so imminent, that I directed the removal of a portion of the fluid, sufficient to relieve the lungs and heart from immediate pressure. This was done to the extent of 28 ounces, with marked relief. Next day she was worse. About 28 ounces of the fluid were again drawn off. As on the former occasion, a fine trochar and canula was inserted between the sixth and seventh ribs, rather behind the axillary line. During the operation I pushed the left crus of the diaphragm upwards by compressing the abdomen on that side, with the effect of increasing the stream during inspiration. In spite of this, however, a small amount of air was drawn into the cavity of the pleura during inspiration. This might have been easily obviated by wrapping a small piece of gold-beater's skin round the shoulder of the canula.

The relief afforded was complete and immediate. Drowsy before, she now looked bright and cheerful, and spoke with pleasure of her relief. The respirations became slower and more full, the pulse stronger and less quick; the face became less dusky, the hands less livid, and the white patch made by pressure on the livid hand, which formerly took nearly five seconds before it was obliterated, now disappeared in about a second. The veins of the neck, previously swollen, even during inspiration, were now quite flaccid.

From that day to this my patient has been gradually improving. The fluid lessened from day to day; the heart returned to the left side. The friction-sound became audible, first below the heart and then behind it. After a time it was heard only during a deep inspiration. At length it disappeared. The lung has gradually resumed its function. She is now quite convalescent.

The presence of permanent distension of the jugular vein in cases of effusion into the pleura is a certain sign of extreme obstruction to the pulmonary circulation, the relief of which, by paracentesis, is immediately demanded. The removal of the venous distension by means of the operation is the immediate indication of the relief of the obstruction to the circulation. If there be no such tension of the jugular veins, even when the accumulation of fluid is very large, the effusion usually disappears with wonderful rapidity. There can, therefore, in a case such as that which I have just described, be no necessity for removing the whole of the fluid, since the effusion will, if left to itself, gradually disappear. Indeed, such a procedure is full of danger. A large additional amount of blood suddenly gorges the pulmonary capillaries. This blood cannot advance, and bronchitis, with copious exudation, is the result. In several cases of paracentesis that have come under my notice, death has been caused, not by pleuritis, but by bronchitis, induced by the operation.

Dr. Bowditch has published many cases in which he successfully performed paracentesis thoracis on Dr. Wyman's plan, by drawing off about thirty ounces of fluid, by means of a syringe attached to an exploring canula, inserted by aid of the trochar.

THE HEART AND GREAT VESSELS.

See Columns 10 *and* 13 *to* 23.

From the inspection of Plate IX., we see that the heart occupies the whole centre of the chest from the sternum to the spine, and that between the sternum and the great vessels a layer of lung is interposed. The descending aorta is fixed in its position to the spine by the intercostal arteries. As, therefore, the sternum advances during inspiration, the layer of lung between it and the great vessels expands, the increased thickness of the lung being proportioned to the advance of the sternum. In the full-chested the sternum is separated from the great vessels by a considerable mass of lung; but sometimes, in the flat-chested, the lungs collapse to such an extent that the great vessels lie immediately behind the sternum.

While the dorsal vertebræ form a curve looking forwards, the sternum forms an arch looking backwards. At the top, the sternum is comparatively near to the vertebræ, the space between being only filled up by the great vessels and the trachea. At the bottom, the sternum is distant from the bodies of the dorsal vertebræ, the space between being occupied by the heart, the aorta, and œsophagus.

The bodies of the vertebræ project forwards into the chest more and more from above downwards, and in proportion as they project forwards, do the ribs curve increasingly backwards. Owing to this arrangement, the mass of lung occupying the dorsum increases from above downwards. We thus see, that, not only is the space for the heart largest in front of the bodies of the lower dorsal vertebræ, but that the space for the mass of lung behind the heart and occupying the dorsum is there largest also. If a horizontal section be made of this portion of the chest, it will be found that the space behind a line drawn across the front of the bodies of the vertebræ, is equalled by the space in front of that line.

The result of the above arrangement of the vertebræ and ribs is, that the lungs chiefly occupy the anterior portion of the chest above, and the posterior portion of the chest below. (See Plate VIII.) In harmony with this arrangement, the upper is the anterior lobe, the lower the posterior lobe; and during inspiration the upper portion of the chest moves forwards to expand the upper lobe, while the lower portion of the chest moves backwards to expand the lower lobe, the diaphragm descending at the same time to complete the expansion.

By the examination of the side view (Plate IX.), we at once recognize that the right ventricle is really the anterior, while the left is really the posterior ventricle. I have removed the fat and cellular tissue from between the pulmonary artery and the left ventricle, so as to expose the origin of the aorta. It may be observed, that the pulmonary artery, at its origin, lies immediately in front of the aorta; thence it passes almost directly backwards, while the aorta ascends almost directly upwards. The two vessels, therefore, cross each other, the pulmonary artery at its bifurcation being immediately behind the ascending and in front of the descending aorta.

If we look at the arch of the aorta in front, as in Plate IV., it has little or no resemblance to an arch, since the ascending is almost in front of the descending aorta. But when we look at it in the side view (Plate IX.), we at once see how truly the aorta forms an arch during the first part of its course.

By comparing Plate IX. with Plates V. and VI. we recognize that the aortic valves lie behind and a little to the left of the pulmonic valves, while the mitral lies behind and a little to the left of the tricuspid valve.

In keeping with this anatomical arrangement, the murmur of mitral regurgitation is louder to the left of the nipple than to the left of the sternum. Inasmuch, also, as the left auricle lies in front of the sixth, seventh, and eighth dorsal vertebræ, the mitral murmur, if heard along the spine, is louder over those vertebræ than it is higher up.

The aortic murmur during systole is conveyed along the great vessels by the current of blood. At first sight we should expect the aortic systolic murmur to be most distinct over the upper bone of the sternum just in front of the aorta. But usually this is not so; that *bruit* being loudest just above and to the right of the top of the sternum, immediately over the arteria innominata. This is particularly marked in the full-chested, since in them the thick layer of lung between the sternum and the aorta, cuts off or muffles the aortic

EXPLANATION OF PLATE IX.

From the same subject as Plate VIII. The left half of the sternum and the greater part of the left ribs have been sawn off, and the left lung, all but the summit of the upper lobe, has been removed, exposing—the heart *in situ*, the pericardium, the pulmonary artery, the left pulmonary veins, the arch of the aorta and its branches, the thoracic aorta, the trachea and left bronchus, the bronchus and the pulmonary artery and vein of the summit of the left lung, and the œsophagus. The inner margin of the right lung, and the descending cava, are seen immediately behind the sternum.

I injected the cavities of the heart and the great vessels with tallow, so that they are larger than they were when first exposed, and when they had collapsed, owing to the escape of blood. The heart, which would otherwise have fallen backwards, was kept in its place by hooks.

The diaphragm and the adjoining ribs and vertebræ were sketched from another subject, since the diaphragm had fallen out of its place in the body from which Plates VIII. and IX. were taken, owing to its partial removal, in order to show the stomach and spleen through the intercostal spaces.

In the abdomen, the intestines, all but the lower colon, have been removed, exposing—the œsophagus and the cardiac extremity of the stomach, the spleen, pancreas, and liver, the left kidney and ureter, and the abdominal aorta and ascending cava.

From manifest causes, it is difficult to represent the organs exactly *in situ* in a side view, but I am justified in saying that their position is accurately given in this plate.

(Reduced from 36 inches to 21.)

systolic murmur. In the flat-chested, however, or when the aorta is atheromatous, and consequently dilated and lengthened, so as to advance towards the sternum, the aortic systolic murmur is often louder over the upper bone of the sternum than it is over the innominata.

Usually, the second sound of the aorta is simultaneous with that of the pulmonary artery. When we listen over the sternum, therefore, we cannot tell whether we hear the second sound of one artery or of both. It is otherwise over the neck, since, if the second sound be audible over the carotids, we know that the valves of the aorta are efficient, for the second sound of the pulmonary artery never extends above the sternum.

If we fail to hear the second sound over the arteries in the neck, we may suspect aortic regurgitation. The aortic diastolic murmur, indicating aortic regurgitation, is scarcely ever audible over the arteries in the neck, since the regurgitating current of blood conveys the murmur, not along the vessels, but back into the heart. Practically, we hear the aortic diastolic murmur loudest just to the left of the sternum, over the fifth and sixth cartilages. This murmur is also generally audible, though with less intensity, over the middle and upper half of the sternum, and to the left of the nipple. I see no reason, upon anatomical grounds, why the aortic diastolic *bruit* should be louder over the fifth left cartilage than elsewhere, since, at that place, the right ventricle and its contents are interposed between the aortic valves and the cartilages. One would rather have anticipated that the murmur in question would be loudest to the left of the nipple, since the blood regurgitates directly into the left ventricle, the walls of which usually adjoin the nipple.

I have a patient now in St. Mary's Hospital, a boy, in whom we can always hear a mitral murmur to the left of the nipple, and an aortic systolic murmur above the sternum, the second sound being there absent. The impulse of the apex protrudes with remarkable force to the left of the nipple line, so as to widen the space between the fifth and sixth ribs. Convinced that the aortic valves were inadequate, I listened several times for a diastolic aortic murmur, but unsuccessfully. After a ten minutes' examination, however, I one day heard, over the left fifth and sixth cartilages, a fine musical *bruit* which was audible to every one. He then walked quickly to the end of the room and back again, with the effect of silencing the sound. In this patient the murmur is evidently only audible when the heart's action is somewhat quieted. The case proves that we cannot always pronounce on the presence or absence of a murmur from a cursory examination; and that the observation of the increased size and force of the left ventricle aids us in detecting disease of the aortic valve, in the same way that the increased force and size of the right ventricle aids us in detecting disease of the mitral valve.

Owing to the anatomical position of the thoracic aorta in relation to the vertebræ, the aortic systolic *bruit*, when audible over the back, is loudest over the third dorsal vertebra; in this respect contrasting with the mitral murmur, which is loudest over the eighth vertebra.

I have given the anatomical position of the various heart-sounds, in some points with greater detail, in columns 21 and 22; but I think it well to bring them again into view, in immediate connection with the anatomical relations of the heart and great vessels.

The origin of the pericardium from the central tendon of the diaphragm is shown in Plate IX. The descent of the diaphragm necessarily involves that of its central tendon, upon which, as upon a floor, the heart rests. The heart, therefore, follows the movements of the diaphragm, being lowered in position by its descent, raised by its ascent.

But the diaphragm exerts in addition an indirect action on the movements of the heart, through the medium of the lungs. When the base of the lung is lowered by the diaphragm, the whole lung is lengthened, and every part of it, in a diminishing ratio from base to apex, is lowered. The inspiratory descent and expiratory ascent of the bronchi, where they enter the lungs, are considerable, and are indicated by the corresponding respiratory movements of the larynx. The heart is intimately attached to the lungs posteriorly by the pulmonary veins and arteries, the former of which leave the lung just below the bronchus, while the latter penetrate the lung just above the bronchus. The heart, therefore, necessarily moves with the movements of the lungs, and it is drawn downwards during inspiration by the diaphragm, indirectly through the medium of the lungs, as well as directly by means of the central tendon.

The automatic and respiratory movements of the heart and great vessels are illustrated to a certain extent by the remarkable case of M. Groux, an intelligent German, who is the subject of congenital fissure of the sternum. When he sits still, the fissure is $\frac{8}{10}$ of an inch wide above the middle of the sternum. Below, the opposite sides approximate, and are held together by the articulations of the sixth and seventh costal cartilages. The fissure is rather more to the right than the left side of the sternum.

In the hollow of the fissure appears a pulsating tumour, which varies greatly in size. During a deep inspiration, when the sternum rises and advances, the hollow is deep, and the tumour is small or absent. It then appears and disappears alternately, just at the lower part of the fissure, with the alternate systole and diastole of the heart. During a forced expiration, when the sternum is lowered and falls backwards, the hollow is obliterated by the advance of the tumour, which swells forwards and upwards, so as to rise above the level of the sternum. The same effects are induced when he exerts himself, speaks much, or holds his breath, or presses the sternum backwards with his hands. This pulsating tumour is the aorta.

During *tranquil breathing*, the aorta, at the beginning of the systole, starts suddenly upwards and forwards, advancing from $\frac{5}{100}$ to $\frac{10}{100}$ of an inch; during the progress of the systole, it gradually descends and recedes; and at the beginning of the diastole, synchronously with the second sound, it again starts suddenly forwards and upwards. During diastole, when the aorta is at rest, its highest visible part is on a level with the second costal cartilage, being two inches below the upper edge of the clavicle. At the beginning of the systole, the summit of the aorta ascends $\frac{2}{8}$ of an inch; during the progress of the systole, it descends from $\frac{5}{8}$ to $\frac{6}{8}$ of an inch; and at the beginning of the diastole, it suddenly resumes its original position.

The finger, when placed over the aorta, is pushed steadily forwards at the beginning of the systole. At the beginning of the diastole, synchronously with the second sound, the aorta recoils upon the finger with a peculiar sharp fillip or impulse. The aortic beat can be felt to the extent of one inch.

The beat of the arteria innominata is felt between the clavicles. The ordinary beat is felt during systole, and a second beat, or fillip, which is sharper and stronger than the systolic beat, is felt at the beginning of the diastole.

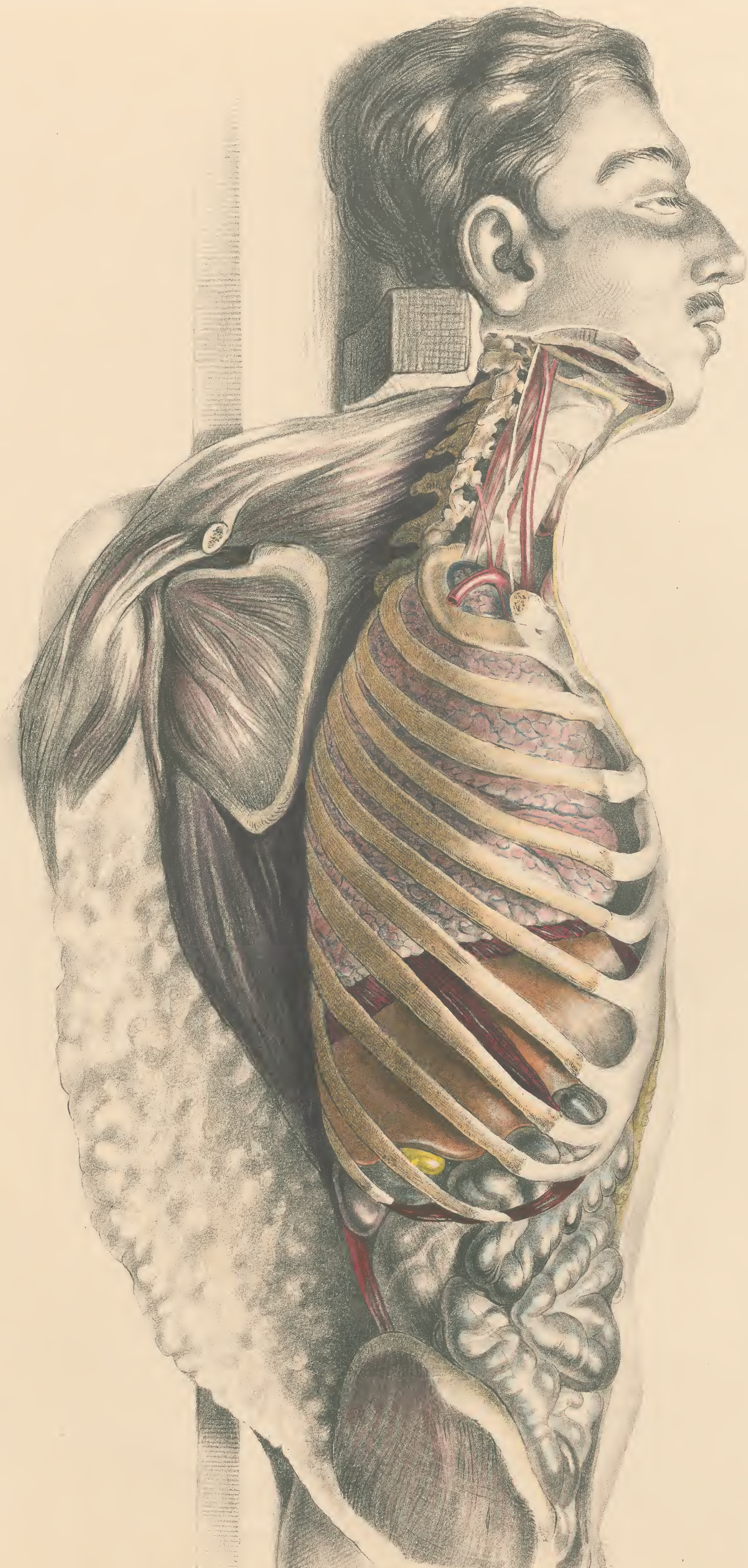
During a *deep inspiration*, the summit of the aorta is two inches and a half below the upper edge of the clavicle. At the beginning of the systole it ascends $\frac{1}{8}$ of an inch; during the systole, it descends $\frac{4}{8}$; and at the beginning of the diastole it again springs upwards $\frac{3}{8}$ of an inch. At the end of the systole the aorta almost disappears.

At the end of a *forced expiration*, the top of the aorta, at the beginning of the systole, is within an inch of the upper edge of the clavicle; during the systole it descends one inch; and at the beginning of the diastole it springs upwards about half-an-inch.

During tranquil breathing, and during a deep inspiration, the aorta alone is apparent, occupying the lower third or half of the fissure. During forced expiration, however, while the aorta rises, the sternum descends, and the top of the aorta is an inch and a half higher in relation to the sternum than it is during a deep inspiration. The result is, that at the end of a forced expiration, the right auricle occupies the fissure to the extent of an inch in addition to and just below the aorta. The auricle bulges forward beyond the aorta towards the end of the systole, and it evidently moves, during the systole, across the fissure from right to left. The movements of the auricle are almost as apparent to the eye as those of the aorta; but when the finger is applied over the former its movements can scarcely be felt, although the movements of the latter can be felt with considerable force. In fact, the movements of the auricle are seen rather than felt. Considering that the right auricle moves to the extent of about an inch from right to left during the ventricular systole, and then back again from left to right during the diastole, the right ventricle must, during the latter period, in part replace the auricle just below the aorta. Consequently, during a forced expiration, the right ventricle must in part occupy the fissure alternately with the right auricle.

It is clear that the pulsating tumour is the aorta, and that the strong double pulsation felt between the clavicles is caused by the arteria innominata, for those vessels occupy the same position in the dead body that the pulsating tumour and the double pulsation occupy in this case.

Drawn from the Subject & on Stone by William Fairland



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Pl. X.

COMMENTARY ON PLATES X. & XI. AND ON PLATES VIII. & IX. *(resumed.)*

THE RIBS AND INTERNAL ORGANS VIEWED FROM THE SIDE.

THE RIBS AND STERNUM IN RELATION TO THE IMMEDIATELY SUBJACENT ORGANS.

The description at column 29 of the direction of the various ribs on the left side (Plate VIII.), applies also to their direction on the right side (Plate X.).

Plates VIII. and X. show that the cage of the chest, composed of the ribs and sternum, and containing the lungs immediately within it at its two upper thirds, the diaphragm at its lower third, presents itself on each side in the form of a cone. The apex of this cone is at the articulation of the first rib: its base extends like a girdle across the lower ribs, from the end of the eighth rib in front to that of the twelfth rib behind. By the base of the thoracic cone, I mean the circuit at which the pleura is reflected from the diaphragm upon the ribs and intercostal muscles, and down to which the lungs can descend during the deepest possible inspiration in the living, and when distended to the full in the dead. This base, or line of the diaphragmatic reflection of the pleura, crosses within the ninth, tenth, and eleventh ribs, a little above the junction of each rib, to its cartilage. During ordinary, and still more during forced expiration, the downward obliquity of these ribs increases, and their ends are lowered, that of the tenth being the lowest. They consequently present a convex edge looking downwards into the flanks, towards the crest of the ilium. The result is, that the base of the thoracic cone describes, in the tranquil state, a convex curve, looking downwards, which at its lowest part crosses within the lower end of the tenth rib. In Plates VIII. and X., as well as in Plate I. (front view), the diaphragm is cut away to show the abdominal organs through the lower intercostal spaces; but in Plate II. the diaphragm is retained, and in that Plate the line at which the pleura is reflected from the diaphragm to the costal walls, is indicated in the seventh right intercostal space at its lower end.

The cone of the chest increases rapidly from its summit down to the fourth cartilage in front, and the eighth rib behind, in Plate X.; and to the sixth cartilage in front, and the eleventh rib behind, in Plate VIII.; those being the cartilages and ribs which respectively correspond with each other, if a tape be tied round the chest. The antero-posterior diameter of the chest scarcely increases, from the points indicated, down to the base of the thoracic cone. The sternum partakes of the advance of the cartilages forwards; but while it advances more rapidly than they do, down to the articulation with it of the second costal cartilages, they advance more rapidly than it below that point, since the cartilages, from the third to the sixth, project more and more beyond the level of the sternum.

During a deep inspiration, the thoracic cone, viewed from either side, increases markedly in diameter as low as the sixth or seventh cartilages, in front, and the tenth or eleventh rib, behind. In the robust, the chest has more or less the set of inspiration, so that the diameter of the chest widens downwards to a greater extent in them than in the slender and flat-chested, as is well illustrated by comparing Plate VIII. with Plate X. If a line be dropped downwards, from the origin of the outer scalenus to the base of the chest, at the top of the tenth rib, it will be found to divide the lateral cone of the chest equally. This line is called by Conradi the "axillary line." It is an interesting physiological fact in the mechanism of respiration, that all those parts of the costal walls that are in front of this line move forwards, while almost all those parts behind that line move backwards during a deep inspiration, as I have described in a paper on the Mechanism of Respiration, in the Philosophical Transactions for 1846.

At the same time that the costal walls advance in front of the axillary line, and recede behind it, during a deep inspiration, the sternum and the whole of the ribs, from the fifth to the eleventh, are raised to an extent corresponding rib for rib to the degree to which the chest is deepened. The twelfth rib is stationary. The effect on the contour of each rib, as well as that of the whole chest, is remarkable. The curves of the ribs, and the width of the intercostal spaces, described above in column 29, are universally modified. Instead of the six superior ribs presenting a convexity looking downwards, and the seventh, eighth and ninth ribs a convexity looking upwards, with the necessary result that the upper intercostal spaces are wide, while the lower and especially the intermediate spaces are narrow, the ribs being there crowded together,—the whole of the ribs become, during a deep inspiration, more nearly parallel, the four upper ribs and cartilages converge, so as to narrow their intercostal spaces, while all the lower ribs diverge, so as to widen their intercostal spaces to a marked extent. The depending position of the extremities of the tenth and eleventh ribs is completely altered by the elevation and unfurling of those and the adjoining ribs, and instead of projecting downwards with a convex curve towards the ilium, they are nearly on the same level, so that a girdle tied round the body would cross in succession the extremities of the three lower ribs. The base of the thoracic cavity, formed by the reflection of the pleura from the diaphragm to the ribs, is at the same time raised, and presents, instead of a convexity looking downwards, an almost straight line, crossing the extremities of the four lower ribs in an oblique direction from before backwards and downwards. The result is, that the whole costal walls are raised above, shortened below, and deepened throughout.

In emphysema, the cone of the chest presents, on a side view, the form of deep inspiration, exaggerated and modified. Owing to the great expansion of the lungs, the chest is abnormally deep; the ribs are raised above so as to shorten the neck, and below so as to shorten the costal walls and lengthen the abdomen. Behind the axillary line the ribs, especially the lower ribs, protrude backwards, and the spinal column presents a backward curvature amounting to a deformity. In front of the axillary line, the upper ribs and the sternum are unusually high and prominent, but the lower end of the sternum and the sixth and seventh costal cartilages are markedly depressed, being forced backwards by the atmospheric pressure from without, induced by the imperfect entrance of air through the bronchial tubes. The upper intercostal spaces are narrowed, and the lower are widened to an abnormal extent.

In phthisis, the cone of the chest presents, on a side view, the form of deep expiration, owing to the collapse of the lungs. The chest is flat; the ribs are lowered above so as to lengthen the neck, and below so as to lengthen the costal walls and shorten the abdomen.

EXPLANATION OF PLATE X.

This Plate and Plate XI. represent views of the right side of the body. Taken from a well-formed man, aged 20, who died of fever.

In this Plate the ribs are left, the intercostal muscles being removed. The diaphragm, where it is immediately subjacent to the lower ribs, has been cut away, all but a thin edge immediately below the base of the lung, and a slip of the muscle extending upwards and backwards from the tip of the eighth rib and costal cartilage.

The right lung, the liver, and gall-bladder, and a portion of the colon, are seen through the intercostal spaces.

In the abdomen, the caput cœcum coli, the ascending and transverse arches of the colon, and a portion of the small intestines are exposed. The lower two-thirds of the right kidney are seen behind and below the liver and the eleventh rib, and in front of the quadratus lumborum.

(Reduced from $32\frac{1}{2}$ inches to $18\frac{3}{4}$).

Behind the axillary line, owing to the collapse of the lungs, the ribs are contracted, and the spine is usually straight. In front of the axillary line, the upper ribs and the sternum are unusually flat; but, owing to the liver remaining of the normal size, or becoming enlarged by fatty degeneration, the seventh or even the sixth and the lower ribs are often unusually prominent. The upper intercostal spaces are widened and the lower are narrowed to an unusual extent.

The lower edge of the right lung,—which in Plate I., from a robust man, is behind the lower edge of the sixth cartilage, and in Plate II., from a slender youth, is behind the fifth intercostal space—is, in Plate X., as high as the upper edge of the fifth cartilage, owing to the collapse of the lung. Thence the base of the right lung, in Plate X., passes backwards with a slight downward obliquity, crossing in succession the sixth, seventh, eighth, ninth, and tenth ribs, and their intercostal spaces.

In Plate VIII., which presents a view of the left side, the base of the lung is anteriorly behind the sixth rib and cartilage. Thence it passes backwards, with a downward obliquity, crossing in succession the seventh, eighth, ninth, tenth, and eleventh ribs, and their intercostal spaces. The position of the base in Plate II. corresponds with that in Plate VIII., but it is a rib's breadth lower in Plate I., taken from a robust man. In comparing the left side with the right in Plates I. and II. (front views), VIII. and X. (side views), and XII. (back view), it will be seen that the base of the left lung is, throughout, lower than that of the right lung, to the extent, in front, of about a rib's breadth, behind, of about half a rib's breadth. During a deep inspiration, and when the lungs are distended after death to the full, the right base approximates nearly to the level of the left base. The difference between the right and left base is consequently but slight in those affected with emphysema, while it is often very marked in those affected with phthisis, in whom, indeed, the increased size of the liver presents an additional hindrance to the descent of the base of the right lung.

During a deep inspiration, the base of each lung is lowered about one inch. While the base of the lung moves downwards, the base of the thoracic cavity along the line of the reflection of the pleura, moves upwards, and to about the same extent. The lungs are, indeed, arrested in their downward expansion by the line of the reflection of the pleura at the base, especially in cases of emphysema. The base of the expanded lung is still somewhat lower behind than before, but, instead of presenting a concavity, it presents a convexity, looking downwards. The lower edge of the right lung, which was previously behind the lower end of the sternum, descends during a deep inspiration to the tip of the xiphoid cartilage. The base of the expanded lung anteriorly is, in consequence, no longer comprised within the costal walls, but it lies behind the abdominal muscles, above a line passing from the tip of the xiphoid to the free edge of the eighth cartilage.

During a deep expiration all these processes are reversed: the chest is flattened; the ribs being lowered, crowd together below, and are lengthened downwards towards the ilium; the base of the lung rises; while the line of the reflection of the pleura, forming the base of the thoracic cavity, descends, and becomes more convex downwards.

In the robust and full-chested, the base of each lung is habitually low, approaching to the fulness and position of inspiration. In the slender and narrow-chested, on the contrary, the base of each lung is habitually high, approaching to the collapse and position of expiration. Hence the position of the base of the lung varies so much in different bodies, when examined after death. Thus, in Plate I., from a robust man, the base of the right lung extends from below the sternum and the sixth intercostal space in front, to below the eleventh rib behind, crossing the ninth rib at the axillary line; while in Plate X. it extends from above the lower end of the sternum, and the upper edge of the fifth cartilage in front, to the tenth rib behind, crossing the seventh intercostal space at the axillary line.

In emphysema, the base of the lung is lowered throughout, to an extent, in extreme cases, beyond that to which it descends in health during the deepest possible inspiration, so that it extends from below the tip of the xiphoid cartilage in front, to below the spring of the twelfth rib behind. In phthisis, on the other hand, the base of each lung is often unusually high, because of the shrinking of the lungs themselves, and often, also, on the right side, from enlargement of the liver.

The bases of the lungs are abnormally high when the abdomen is distended from any cause, whether from gastro-intestinal distension, ascites, abdominal tumours, or ovarian dropsy. Thus, in a case of

extreme gastro-intestinal distension (see Medical Gazette, New Series, Vol. VII., p. 107), the base of the right lung was behind the fourth intercostal space in front, and the sixth rib at the side, the left base being proportionately high. When the stomach is excessively distended, the left base is raised to a greater extent than the right. When the liver is simply enlarged, it does not necessarily elevate the base of the right lung, since, owing to its weight, it makes its way downwards into the abdomen, unless the stomach and intestines are distended. When the upper part of the liver is occupied by a large abscess, an hydatid cyst, or a malignant tumour, the base of the right lung is raised to a remarkable extent. Thus, in a case of extensive abscess in the liver (see Medical Gazette, New Series, Vol. VII., p. 107), the base of the right lung is displaced upwards, in front, to the third costal cartilage, and at the side, to the fourth rib.

The size of the middle lobe of the right lung, and, as a necessary consequence, that of the lower and anterior part of its upper lobe also, and the position of the septum between the middle and the upper and lower lobes, vary much in different persons. Thus in Fig. 4, column 29, the inner end of the septum between the upper and middle lobes is just above the lower edge of the right lung, and the lower end of the sternum; in Plate X. it is at the top of the lower fourth of the lung; in Plates I. and II. it divides the anterior portion of the lung into two equal parts, being situated in the third intercostal space; and in the Figure at p. 591, Medical Gazette, New Series, Vol. VI., it is as high as the top of the third costal cartilage. There is less variation in the position of the septum between the middle and lower lobes, which is truly a continuation of that between the upper and lower lobes. Usually the lower end of that septum is seated in the fifth or sixth intercostal space, occupying a position corresponding to that of the lower end of the septum, between the upper and lower lobes of the left lung. With the inspiratory descent of the diaphragm, the middle lobe and its septa occupy a lowered and extended position; the septum between it and the upper lobe moving downwards, while that between it and the lower lobe moves both backwards and downwards. The middle lobe of the right lung is indeed an appendix of the upper lobe, it being the exact analogue of the lower half of the left upper lobe.

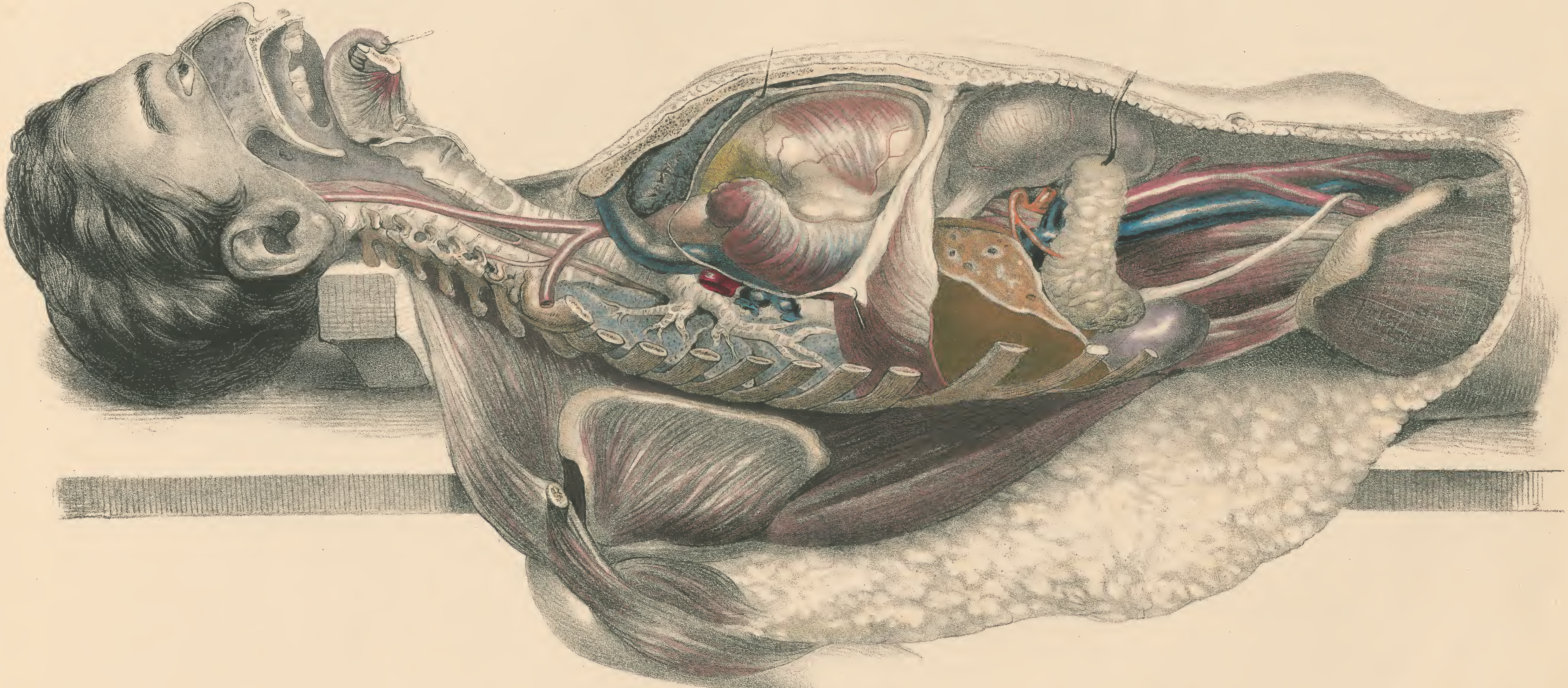
The whole lower edge of each lung can be accurately ascertained by the resonance on percussion, the vocal vibrations, and the breath-sounds which are present down to the base line, and absent below it.

Usually the lower intercostal spaces are hollowed out, owing to atmospheric pressure, down to the lower margin of the lung, while they are filled up below that margin, especially on the right side, owing to the support afforded by the solid liver to the intercostal spaces. This depression of the intercostal spaces, where they are superficial to the lungs, is scarcely apparent in the flat-chested and during expiration, owing to the approximation of the ribs; but during inspiration the lower intercostal spaces are widened, while the base of the lung is lowered; and the increased furrowing of the intercostal spaces exactly indicates the extent of the inspiratory descent of the base of the lung. In the robust and, to a remarkable extent, in those affected with emphysema, the falling inwards of the intercostal spaces over the lung is marked, the lower boundary of the depression indicating to the eye the exact position of the base of the lung.

The extent to which the diaphragm is immediately subjacent to the ribs is, in the nature of things, exactly limited by the base of the lung. Above the base, and as high as the articulation of the first rib, there is nothing but lung; below the base, and as low as the cartilages of the lowest ribs, there is nothing but diaphragm. The height to which the diaphragm rises into the chest corresponds, likewise, with the extent to which the lung is expanded.

The right convexity of the diaphragm is globular or oval, and being wider from behind forwards than from side to side, its summit is, in Plate X., on a level in front with the fourth cartilage at the side with the sixth rib, and behind, with the eighth rib. In Plate IV., from a slender youth, the right summit is as high as in Plate X.; but in Fig. 4, column 15, it is on a level with the fourth intercostal space in front and the sixth at the side; while in Fig. 1, column 13, and in Plate I., from a robust man, it is as low as the fifth cartilage in front and the sixth intercostal space at the side. In the side view given at page 358 of the Medical Gazette, New Series, Vol. VI., the right summit is on a level in front with the fifth cartilage, at the side with the sixth intercostal space, and behind with the tenth rib. The base of the right lung sits like a cap upon the right convexity of the diaphragm. The wedge of lung thus interposed between the diaphragm and the ribs is

PL. XI.



Drawn from the Subject & on Stone by William Fairland

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larger posteriorly than anteriorly, owing to the base of the lung being lower behind than in front.

The left convexity of the diaphragm is usually from one to two ribs' breadth below the level of the right. Instead of the left being oval, like the right, it is more of a half-moon shape, the greater portion of it being behind, owing to the position of the ventricles and apex of the heart in front of the left side of the chest. In Plate IX., which presents a view of the left side, the left summit of the diaphragm is on a level with the lower edge of the fifth costal cartilage in front, and with the tenth rib behind. It is only by viewing the body from before, as in Plates I. and IV., and Figs. 1 and 4, and from behind, as in Plates XII. to XV., that we can compare the relative height of the right and left convexities of the diaphragm. In Plate IV., the left summit is much lower than theright, since, while the former is on a level with the top of the right fourth costal cartilage, the latter is on a level with that of the left fifth.

In Plate I., the convexities of the diaphragm are more nearly on a level, since their summits are respectively behind the fifth costal cartilage, and that of the left crus is scarcely a rib's breadth lower than that of the right. This difference in height of the two sides may depend on the right lung being somewhat more expanded than the left at the time of death, on the stomach and intestines being more or less distended, and on the liver being of greater or less size.

During a deep inspiration, the diaphragm not only descends so as to expand the lungs downwards, and to push before it all the abdominal viscera, but each convexity, and particularly the right, becomes considerably flattened, so that the concavity formed by the upward protrusion of the diaphragm, at the base of each lung, is materially lessened, while the summit of the liver is flattened and compressed downwards. In cases of emphysema, the flattening as well as the lowering of the diaphragm, is permanent.

I have already spoken of the influence of abdominal distension in pushing up the diaphragm, and of that of an abscess or tumour in the upper part of the liver in elevating its right convexity.

So far as physical examination is concerned, those important abdominal organs that are situated in whole or in part immediately within the diaphragm, below the base of the lungs, may be regarded as being immediately subjacent to the lower ribs. The extent to which those infra-diaphragmatic organs are immediately subjacent to the costal walls is ruled by the position of the base of either lung. During expiration, when the diaphragm and the base of the lungs are high, the abdominal organs are shielded by the lower costal walls to a great extent. So much indeed are the higher abdominal organs pushed upwards during a forced expiration, that they lie, especially on the right side, immediately within the costal walls, to a greater extent than the lungs themselves. But while the abdominal, intrude thus on the thoracic organs during expiration, the thoracic, through the agency of the diaphragm, expel the abdominal organs to a great extent from within the costal walls during a deep inspiration.

In the slender (see Plates II. and X.), and particularly in those affected with phthisis, the base of either lung being habitually high, the costal walls flat, low, and long, and the abdominal walls short, the liver and stomach are almost entirely shielded by the costal walls, a small portion only of either organ being seated behind the abdominal walls, just below the xiphoid cartilage. In the robust (see Plate I.), the base of either lung being habitually low, the costal walls full, high, and short, the abdominal walls long, the liver and stomach are only partially shielded by the costal walls, a considerable portion of each organ being seated behind the abdominal muscles. In those affected with emphysema, the base of each lung is so low that the liver and stomach are but slightly protected by the lower edges of the costal walls, those organs being mainly situated behind the abdominal walls.

In Plate X., the liver, although abnormally large, is so completely screened by the costal walls, that its lower margin is an inch above the lower edge of the eighth, ninth, and tenth cartilages, the transverse arch of the colon occupying the intra-costal space immediately below the lower margin of the liver. In Plate II., from a slender youth, the stomach being empty, the colon full, the liver juts a little beyond the lower margin of the costal cartilages, from the seventh downwards. In Plate I., from a robust man, the intestines being rather empty, the liver presents itself to a great extent, both downwards and to the left, behind the abdominal parietes, its lower margin being 2½ inches below the lower edge of the ninth costal cartilage, and 6 inches below the lower end of the sternum. In a drawing from a case of emphysema now before me, the lower margin of the liver is 2 inches below the lower edge of the tenth costal cartilage, and 6½ inches below the lower end of the sternum.

The extent to which the lower and left portion of the liver is screened by the right ribs and cartilages, or exposed behind the abdominal muscles, is affected to a remarkable extent by the distension or collapse of the stomach and intestines. Thus in Plate X., the lower margin of the liver is raised above the lower edge of the costal cartilages by distension of the colon: in Fig. 1, in the 12th vol. of the Prov. Med. Trans., the same effect is induced by distension of the stomach, although the summit of the liver is not abnormally high. In the figure at p. 107 of the 7th vol. of the Med. Gaz., the same effect is caused by excessive gastro-intestinal distension, the summit of the liver being also excessively high; and in a case of fever that I examined at St. Bartholomew's Hospital, the gastro-intestinal distension was so great, as to push the lower edge of the liver upwards and backwards, so that it was above the lower margin of the right lung.

When the stomach is empty, the liver is lowered, and its edge moves so far over to the left as to occupy a large portion of the space within the left lower ribs, below the heart and the base of the left lung, as in Fig. 2, in the 12th vol. of the Prov. Med. Trans. When the intestines as well as the stomach are completely empty, the whole liver drops downwards with a bearing to the left, so that its lower margin may rest on the crus of the right ilium, as in Fig. 8 in the same volume.

The size of the liver itself has a marked influence on the extent to which it is covered by the ribs, or exposed behind the abdominal muscles. If the liver be simply enlarged, as from fatty degeneration or congestion, it does not encroach upwards on the lungs, but downwards on the stomach and intestines, unless, as in Plate X., they are excessively distended. If, however, the liver be occupied in its mass by an abscess, a hydatid cyst, or malignant disease, then the liver enlarges in every direction, and while it pushes the other abdominal organs downwards, it elevates the diaphragm to a remarkable extent, as I have already illustrated, and causes general and marked enlargement of the lower costal parietes over the region of the enlarged organ.

When there is effusion of fluid into the cavity of the right pleura, the liver is displaced downwards in proportion to the extent of the effusion. When the amount of fluid is very great, it causes eversion of the diaphragm downwards into the abdomen, and dislocation of the liver, so that it lies completely behind the abdominal walls.

If the lung is condensed after the disappearance of the effusion, the liver not only regains its normal situation, but rises above it so as to occupy a part of the space previously occupied by lung.

When there is extensive effusion into the pericardium, especially in cases of chronic pericarditis of a low type, the liver, as in Fig. 3, column 14, is displaced downwards by the fluid, so as to lie in great part behind the abdominal parietes. The same effect is induced,

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EXPLANATION OF PLATE XI.

From the same subject as Plate X.

In the Head and Neck.—The right half of the nostrils, palate, fauces, tongue, pharynx, and larynx, have been removed, by a section through their centre, so as to expose the interior of the mouth, fauces, larynx, and pharynx.

In the Thorax.—The right half of the sternum, and the greater part of the left ribs, have been sawn off. The right pulmonary artery and pulmonary veins have been cut across, and the anterior portion of the right lung has been removed, exposing—the pericardium, the right auricle and ventricle, the pulmonary artery, the arch of the aorta, and the descending cava; the trachea and the right bronchus and its ramifications, separately traced, to the upper, middle, and lower lobes; the inner and anterior edge of the upper lobe of the left lung; and the convex upper surface of the right side of the diaphragm. The front of the diaphragm is depressed so as to show the right edge of its central tendon, upon the sloping floor of which rest the right auricle and ventricle.

I injected the right cavities of the heart with water, so that they occupy considerably more space forwards than they did when first exposed, and when those cavities had collapsed, owing to the draining away of blood.

In the abdomen, the greater part of the liver and the whole of the intestines have been removed, exposing—the cardiac orifice of the stomach, the pancreas, the right kidney and ureter, the ascending vena cava and the aorta, which bulges forward too much above its bifurcation.

(Reduced from 33 inches to 19.)

though to a less marked extent, when there is great enlargement of the heart with pericardial adhesions, as in Figs. 23 and 24 in the 12th vol. of the Prov. Med. Trans.; and, though to a still less extent, in cases of enlargement of the heart without adhesions, as in Figs. 20 and 21 in the same volume.

We thus see that the extent to which the liver is immediately subjacent to the costal parietes, the diaphragm being interposed, varies with the position of the base of the right lung, the degree of distension or collapse of the stomach and intestines, the size of the liver itself, and the presence in it of abscesses or tumours, the presence of effusion into the right pleura or of condensation of the right lung, and the existence of pericardial effusion, or of enlargement of the heart with or without adhesion.

In Plate VIII., the stomach, which is moderately distended, is seen through the sixth, seventh, and eighth intercostal spaces, (the diaphragm being cut away,) below the lower margin of the lung. The spleen is seen in a similar position immediately behind the stomach, through the eighth, ninth, and tenth intercostal spaces. The stomach is seated in front of the axillary line, the spleen behind it. The axillary line is indeed the usual and normal boundary of the anterior edge of the spleen. A considerable volume of the convolutions of the colon, and even some of those of the small intestines, are seen through the intercostal spaces below the stomach and spleen.

The extent to which the stomach, spleen, and intestines, viewed as a whole, are comprised within the left lower costal walls, is governed by many of the same causes that affect the like position of the liver within the right lower costal walls. Since the base of the left lung is usually lower than that of the right, the position of the upper surface of the stomach and the upper edge of the spleen, are usually much lower than the upper surface of the liver.

The varying position of the base of the left lung during expiration and inspiration, in the slender and the phthisical, in the robust and those affected with emphysema; the presence of effusion in the left pleura or of condensation of the left lung; the existence of pericardial effusion and of enlargement of the heart, with or without adhesion; exercise precisely the same influence in relation to the extent to which the stomach, spleen, and intestines are situated within the left lower costal walls, that the like agencies do in relation to the extent to which the liver is situated within the right lower costal walls.

What I have already said with regard to the influence of the distension or collapse of the stomach and intestines on the position of the liver within the right lower costal parietes, applies, but with more immediate reference, to the position of the stomach and intestines within the left lower costal parietes. When the stomach is excessively distended, it elevates the base of the left lung, and the lower surface of the heart, pushes the spleen backwards and upwards, and expels the large intestines downwards from behind the left lower costal walls, these walls being themselves rendered more prominent. On the other hand, when the stomach is quite empty, the base of the left lung and the lower surface of the heart are lowered, the left lobe of the liver moves over to within the left lower costal cartilages, the spleen is lowered and moves forwards, and the convolutions of the large, and to a less extent those of the small intestines, ascend within the left lower costal walls, which walls at the same time shrink inwards. When the transverse and descending arch of the colon are much distended, their left and upper portions make way for themselves upwards, displacing the stomach forwards and inwards, even if distended. The spleen makes its way upwards and backwards; and the base of the left lung, and to a less degree, the heart, upwards.

The spleen, when healthy, is subjected to all the influences of displacement of which I have just spoken. But although it is extensively displaced downwards and slightly forwards during a deep inspiration, yet it rarely, even then, protrudes below the lower extremities of the costal cartilages. The spleen, therefore, when healthy, cannot be felt by the hand, under any of the varying circumstances of health. In extreme cases of emphysema, and, still more, when the left pleura is excessively distended with fluid, the spleen may be displaced downwards, so as to be felt below the ends of the costal cartilages.

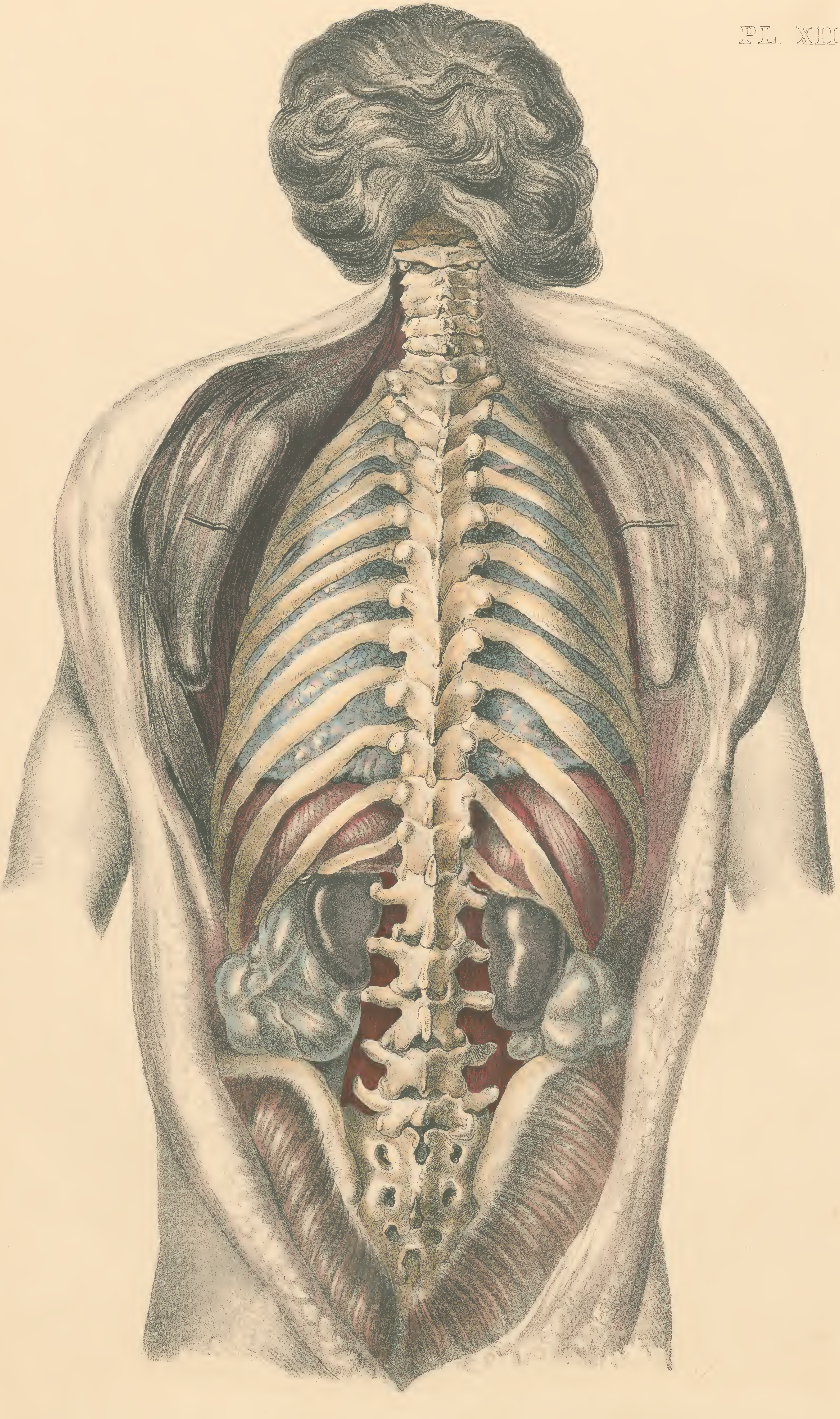
When the spleen is enlarged, its anterior margin advances, according to the degree of enlargement, more and more in front of the axillary line; and while its upper edge extends somewhat upwards, encroaching to a slight degree on the base of the left lung, its lower edge extends downwards towards the ends of the lower costal cartilages. The spleen is still compressed within the left lower costal walls, even when its enlargement is considerable, excepting during a deep inspiration, when it may be felt protruding, as a solid tumour, below the lower ends of the costal cartilages. The enlargement of the spleen, when its boundaries do not transcend the edges of the lower costal cartilages, can only be detected by percussion. If, when the patient lies slightly or altogether on the left side, the anterior boundary of the dulness on percussion, elicited over the spleen, is in front of the axillary line, near the edge of the seventh and eighth cartilages, while its lower boundary is just above the lower ends of the tenth and eleventh cartilages, and if the lower and anterior edge of the organ can be felt, like a solid mass, during a deep inspiration, below the ends of these cartilages, then the diagnosis of a moderately enlarged spleen can be made with precision. In percussing over the spleen, under these circumstances, it must not be lost sight of that when the patient lies on the back, the solid and fluid contents of the stomach gravitate backwards, while its gaseous contents come forwards; consequently, if the stomach be full, the line of dulness on percussion, caused by its contents, may be anterior to the axillary line. If, however, the patient lies on the left side, the solid contents fall inwards, the gaseous contents rise to the side, and the contrast between the gastric resonance and the splenic dulness is marked.

When the spleen is considerably enlarged, its anterior margin advances beyond the edge of the costal cartilages, and can be readily felt through the abdominal parietes as a solid tumour, above which there is pulmonic resonance, but behind which there is neither gastric nor intestinal resonance; this tumour can be displaced somewhat backwards in the direction of the normal position of the spleen, and it is lowered to the extent of an inch during a deep inspiration.

When the spleen is excessively enlarged, it makes way for itself extensively downwards as well as forwards, so as to lie behind the abdominal muscles as low as the crus of the left ilium, and to the right of and below the umbilicus. Under such circumstances, the tumour, if it be spleen, is usually very moveable, being easily pushed upwards and to the left, towards the normal position of the spleen. Its upper margin is bounded by a line of pulmonary resonance on percussion, between which and the tumour there is no gastric or intestinal resonance whatever. In a case of this class under my care in St. Mary's Hospital, the tumour simulated ovarian dropsy; but the existence of intestinal resonance below the lower edge of the tumour, which tended towards the pelvis, corrected the first impression, and the presence of the signs just described led to the conclusion, verified long after by *post mortem* examination, that the spleen was enlarged.

From the examination of the ribs in relation to the subjacent organs, we derive these important practical lessons.—That besides the thoracic organs, the more important of the abdominal organs (the diaphragm intervening) are comprised within the costal walls to a large but varying extent. That when the costal walls are flattened and elongated below, so as to shorten the abdominal walls, the abdomen in reality encroaches upwards on the chest. That when the costal walls are rounded and raised, being shortened below so as to lengthen the abdominal walls, the chest in reality encroaches downwards on the abdomen.—That the liver, even when enlarged, may be completely screened behind the right lower costal walls. That the presence of the liver to a great extent behind the abdominal walls is no sign of its enlargement. That when the substance of the liver itself is enlarged, it tends to encroach downwards into the abdomen, but when its mass is occupied by large abscesses or tumours, it tends to encroach upwards on the chest. That when the liver is disordered pain and oppression may be felt over the right costal walls. That when the liver is affected with peritonitis, friction sounds may be audible over the right costal walls, so as to stimulate pleuritis. That when the liver is tender to the touch we ascertain it by pressing upwards below the edge of the right costal cartilages; when it is firm from congestion, by its offering there a resisting instead of a yielding surface; and when it is indurated by disease, by its presenting a hard solid edge and surface.—That the stomach is in great part seated within the left lower costal walls, just below the heart and the base of the left lung; that therefore the stomach sound on percussion is there elicited; and that gastric pain is felt there as well as at the xiphoid cartilage and between the scapulæ. That gastric distension causes prominence of the left lower costal walls, and compresses the heart and left lung upwards so as to excite palpitation, pain in the cardiac region, and dyspnœa; and that in gastritis, pain is excited by exerting pressure, not directly over the costal or abdominal walls, but upwards under the edges of the left costal cartilages.

PL. XII.



COMMENTARY ON PLATES XII., XIII., XIV. & XV.

THE SPINAL COLUMN, THE RIBS, AND THE INTERNAL ORGANS VIEWED FROM BEHIND.

Although in the living the physical examination of the lungs is equally practised over the back and the front of the chest, yet the internal organs are seldom or never examined in the dead from the region of the dorsum. Teacher and pupil alike disregard the relation of the scapulæ, ribs, and vertebræ to each other, and to the trachea and lungs, the heart and great vessels, the diaphragm and the abdominal organs. The physical examination of the dorsum, although constantly practised, is consequently vague and unsatisfactory.

This ignorance of the position of the internal organs behind is due to the fact that the teaching of anatomy is almost entirely conducted by minute anatomists and surgeons. I trust that the physician will soon share with them that important duty; and that, while they teach minute and surgical anatomy, he will teach medical anatomy. We shall auscultate, percuss, and observe the outer forms of the body in vain, unless we know the proper position of those internal organs whose condition we would discover.

THE SCAPULÆ.

The play of the scapula is greater than that of any other bone, so as to allow of the free and varied movements of the arms, and the extensive ascent of the scapulæ during a deep inspiration.

The following observations as to the exact extent of the mobility of the scapulæ were made on the person of a well-formed young man, now in St. Mary's Hospital, who had recently recovered from intermittent fever. When he stands erect, the arms pendant, the dorsum of the scapula is nearly but not quite flat, its spine inclining slightly forward towards its acromial end. The spine is nearly horizontal, being almost on a level with the clavicle. The apex of the chest, composed of as much of the first four ribs as appears above the scapula, is interposed in the form of a cone between that bone and the clavicle. The opposite scapulæ are $5\frac{1}{2}$ inches apart at the spines, and 6 inches at the lower angles. The spine of the scapula at the base is on a level with the third dorsal spine, and the lower angle of the scapula is on a level with the eighth dorsal spine; the lower angle is above the ninth rib. When he throws his arms backwards, so as to approximate the scapulæ as much as possible, the spines are about $1\frac{1}{2}$ inch asunder, the lower angles about 3 inches. When he stretches the arms upwards and forwards, so as to separate the scapulæ as far as possible, the spines are 9 inches asunder, the lower angles 13 inches. When he crosses his arms over his head, the lower angles, which project at each side, are $16\frac{1}{2}$ inches apart. When he shrugs his shoulders as high as possible, the spines are on a level, at the base of the scapula, with the first dorsal spine; while each acromion is on a level with the third cervical vertebra. The spines of the scapulæ, instead of being horizontal, are inclined obliquely upwards at an angle of about 65°.

The play of the scapulæ is so great, that, at first sight, one naturally infers that they are of no value as landmarks for ascertaining the position of the ribs, and the internal organs. This is not so, however, for the extent to which they can be drawn downwards is very definitely limited, owing to their attachment to the body, and the pivot of their movement being fixed at the sternal end of the clavicle. In slender persons, however, and especially in the phthisical, the scapulæ, owing to the narrowing of the ribs, and the lowering of the sternum, can be drawn downwards to a greater extent than in the robust, and especially in those affected with emphysema. In examining the upper part of the dorsum, it is well to direct the patient to rest his arms on his thighs, with his hands overlapping each other and hanging between them, so as to lower the shoulders and scapulæ as far as possible. On this plan, which is practised by Dr. Williams, and which obviates the tension of the muscles, the scapulæ and the trapezii grasp the ribs, especially the upper ribs, as closely as possible, thus affording an equal tense surface for percussion. When the young man, the movements of whose scapulæ have been just described, stretched his arms downwards in the method indicated, the spines of the scapulæ, which were on a level with the fourth dorsal spine, were $8\frac{1}{2}$ inches apart, the lower angles being 10 inches apart.

When the scapula is in this position in a healthy person, its spine is usually just over the septum, between the upper and lower lobes; consequently, the space above the spine is occupied by the summit of the upper lobe; that below it, by the upper part of the lower lobe. Below the spine, the scapula is superficial to the upper and, from its overlapping the upper lobe, the less bulky half of the lower lobe, the lower and more bulky half of that lobe being below the lower angle of the scapula.

During inspiration, the scapulæ seem to ride on the thoracic walls, being apparently elevated and displaced forwards and to each side by the thrust of the expanding ribs. In reality, however, the scapulæ, instead of being lifted up by the ribs, are withdrawn from them during their inspiratory movements, by a combination of independent forces operating immediately upon the scapulæ. I will consider what those forces are, after describing the inspiratory movements of the scapulæ in the young man convalescent from ague.

When he takes a deep breath, the upper end of the sternum, the clavicles from end to end, and both shoulders, move forwards one inch, and upwards one inch; the acromial end of the spine of the scapula, necessarily put in motion by the sternum and clavicles, advances and ascends to the same extent, while the end of the spine at the base of the scapula only moves forwards three-quarters of an inch. The space between the bases of the scapulæ is widened, so that at their spines it is increased from $4\frac{2}{5}$ inches to $5\frac{1}{10}$ inches, and at the lower angles from $5\frac{1}{10}$ inches to 7; while the spines at the base ascend from the level of the third to that of the second dorsal spine, and the lower angles ascend from the level of the eighth to that of the sixth dorsal spine.

It results from these movements that, during a deep inspiration, the clavicles, shoulders, and scapulæ are raised and drawn forward by the forward ascent of the sternum. The scapulæ are directly elevated by the combined action of the levatores anguli scapulæ, the trapezii, and perhaps the rhomboidei. Owing to their common elevation to the extent of an inch, the clavicle and scapula form a screen, which conceals the third, the second, and the greater part of the first ribs. The cone formed by those ribs in the neck therefore disappears, being replaced behind by the massive rigid fibres of the trapezius, and in front by a deep hollow behind the forward sternum and clavicles. The neck is shortened, and the shoulders become square. The spine of

EXPLANATION OF PLATE XII.

The Plate represents a superficial view of the internal organs as seen from behind; the ribs and vertebræ, and the diaphragm, being left *in situ*.

Previously to making the dissection, the trachea was tied. The vertebræ and ribs were then completely denuded, and the intercostal muscles were removed so as to expose the lungs and diaphragm through the intercostal spaces.

The septum between the upper and lower lobes of the lung is shown on each side, between the third and fourth ribs. The diaphragm comes into view below the base of each lung, a larger portion of it being exposed on the right than the left side. In this Plate,

otherwise correct, the lower ribs are thicker than they ought to be, where they approach the sides of the body.

Below the diaphragm, and to each side of the upper lumbar vertebræ, the kidneys are exposed, the upper portion of them being concealed by the lower portion of the diaphragm.

The ascending arch of the colon is seen to the right of and below the right kidney, outside the fourth and fifth lumbar vertebræ, and above the crest of the ilium. The descending arch of the colon is, in like manner, exposed on the left side.

(Reduced from $34\frac{3}{4}$ inches to $18\frac{3}{4}$.)

the scapula, instead of being parallel with the clavicle and flat over the back, inclines obliquely forwards and upwards, so as to render the back round and stooping. The interscapular space is widened, and raised to a greater extent below than above. The scapulæ are thus lifted outwards from behind the ribs; so that the lower angle, which at the beginning of inspiration rests on the ninth rib, at the end of it rests on the seventh.

I have long endeavoured to ascertain the effect induced by the contraction of the subclavius muscle, and the cause of the eversion of the scapula, especially at the lower angle. I observed in a patient, a very lean man, suffering from emphysema, that the subclavius acts during each inspiration. I think it probable that this muscle causes eversion of the scapula by acting upon it through the clavicle. This eversion permits the seventh and eighth ribs, no longer restrained by the superposition of the scapula, to move more freely backwards during inspiration, so as to aid the lower ribs in the dorsal expansion of the lower lobes.

The above observations show that all the movements of the scapula, brachial as well as respiratory, are more restrained at the upper than the lower angle. The comparative restraint on the upward, outward, and downward movements of the upper angles is caused by the shortness of the fibres of the trapezius inserted into the inner end of the spine of the scapula; while their forward movement is almost prevented by the ribs just in front of them.

In those affected with emphysema, the scapulæ and the walls of the chest assume, to an exaggerated degree and in a modified manner, the position of deep inspiration. The sternum is high and prominent, the neck is short, and the shoulders are high and forward. The clavicles and scapulæ are raised, so as to conceal the cone formed by the upper ribs, and to present instead, in some cases, a deep hollow between the clavicle and the trapezius. Owing to the increased support afforded to it by the fulness of the chest, the scapula is moved upwards and outwards, and sits closely upon the ribs. The result is that the base is withdrawn from the spinal column, especially at the lower angle; the interscapular space is widened and raised; the spine of the scapula, which is unusually high, inclines obliquely forwards and upwards from the base to the acromion; the lower angle is just above the seventh rib; and the whole scapula, instead of being flat, inclines obliquely upwards and forwards, from the base to the acromion.

In the very slender, and still more in those affected with phthisis, the scapulæ, as well as the walls of the chest, take up the position of deep expiration. The sternum is low and flat, the neck is long, and the shoulders are sloping. The clavicles and scapulæ are lowered, so as to expose above them, to an unusual extent, the upper portion of the cone of the chest, which is narrow, owing to the contraction of the upper lobe. Owing to the collapse of the ribs, the scapula, especially on the affected side, loses its support, and drops downwards, falls inwards, and projects backwards, particularly at the lower angle. The result is, that the base protrudes and approximates to the spinal column, especially at the lower angle; the interscapular space is narrowed and lowered; the spine of the scapula, which is unusually low, is either horizontal, or inclines downwards from the base to the acromion; the lower angle is just above the tenth or eleventh rib; and the whole scapula, instead of being flat, protrudes obliquely backwards from the acromion.

The interscapular space includes those important organs, the trachea and its bifurcation, and the roots of both lungs, the œsophagus and aorta, and the heart and great vessels. The dorsal spines form a series of landmarks, which accurately indicate the normal position of those organs. I will, therefore, defer the consideration of their relative bearings, until I describe the spinal column.

THE SPINAL COLUMN AND THE RIBS.

The cage of the chest, composed of the ribs and dorsal vertebræ, viewed from behind, presents itself as a cone, widening at each side from above downwards, and attaining its maximum width just where the ninth rib disappears from view, as it turns from behind downwards and forwards. This broadest part of the cone of the chest is in a line with the spine of the twelfth dorsal vertebra, so that a girdle tied round the body at the point in question would, at the centre, cross the twelfth dorsal spine, and at each side, the lower edge

of the ninth rib. Just below this, the broadest part of the cage of the chest, the outline of the lower ribs, the tenth and eleventh, narrows inwards on each side for the extent of about an inch and a-half.

The cone of the chest, just described, does not widen with an equal and gradual increase from above downwards. It may be observed, that the cone progressively increases in width from the first rib to the fourth; that it retains nearly the same diameter over the fourth, fifth, and sixth ribs, its sides being there almost perpendicular; and that it becomes suddenly wider at the seventh rib, whence it increases in size down to the lower edge of the ninth rib. The seventh, eighth, and ninth ribs thus present a bulge on each side. This bulge corresponds on the right side with the liver; on the left side, with the stomach and spleen, in addition to the base of either lung.

The ribs, from the first to the eighth or ninth, cannot be distinguished by touch over the dorsum, even of thin persons, owing to the muscles by which they are covered, and to the position of the scapulæ. The attachments of the ribs to the transverse processes of the vertebræ, cannot be felt at all. The dorsal spines can, however, always be discovered by pressure, and they form a series of landmarks, whereby we may accurately infer the position of each rib, at its spring from the spinal column.

Each dorsal spine, owing to its low position and downward direction, is on a level, not with the rib corresponding to its own vertebra, but with a lower rib. The last cervical vertebra, which may usually be known by its marked prominence, is on a line with the articulations of the first ribs. The first, second, and third dorsal spines, which have, like the lowest cervical spine, a direction as much backwards as downwards, correspond respectively with the articulations of the second, third, and fourth ribs.

The first three dorsal spines, like the lowest cervical spine, project backwards as much as downwards, at an angle of about 45°, are not attached closely to each other, and enjoy some play of movement during the varying flexure of the neck. The dorsal spines, from the fourth to the ninth, differ materially in direction from the first three, since they are lengthened almost directly downwards, at an angle of about 85°, overlap closely one upon the other, being attached by firm ligaments, and enjoy only a slight play of movement during the bendings of the body and the movements of respiration. The result is, that the tips of most of these spines indicate the second rib below them; so that the fifth spine is intermediate to the spring of the seventh ribs.

The three lower dorsal spines assimilate gradually to the lumbar spines, their direction being less and less downwards, more and more backwards; so that the twelfth dorsal spine projects, like the first lumbar, almost directly backwards. The tenth spine corresponds with the spring of the eleventh rib, while that of the twelfth rib is intermediate to the spines of the eleventh and twelfth dorsal vertebræ.

The spines of the vertebræ form a series of important landmarks, for ascertaining during life the normal position of the subjacent organs.

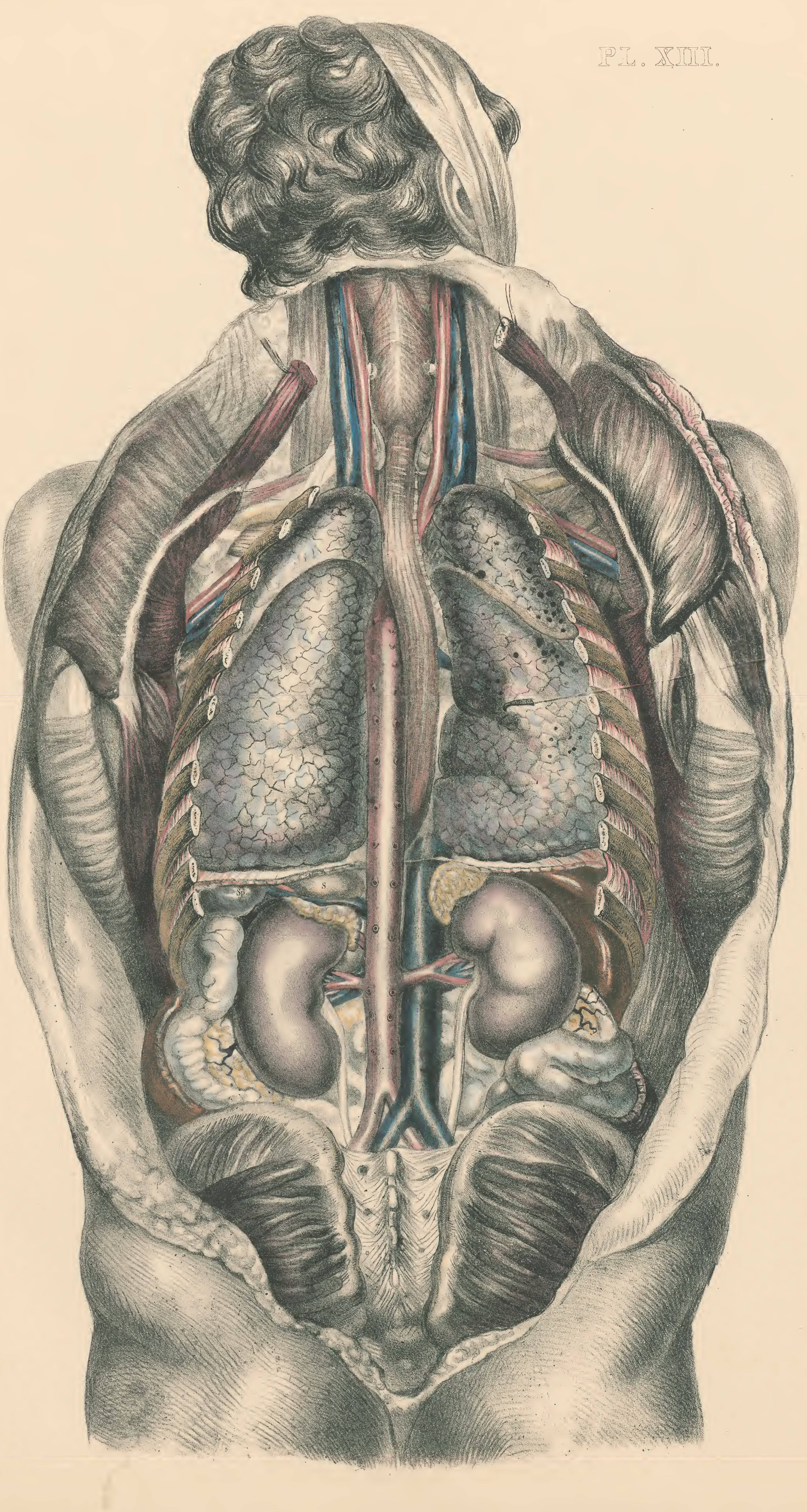
The apex of each lung is on a level with the lower edge of the first cervical spine. The space between the second and third dorsal spines is intermediate to the upper edge of each lower lobe; while the base of the lower lobe, in the dead body, is on a line with the tip of the tenth dorsal spine, the left base being just below, the right just above, the tip. In the living body, however, the base of each lung is about a rib's breadth lower than in the dead.

The lower edge of the diaphragm is seated to each side of the twelfth dorsal spine, and the base of each lung descends, during a deep inspiration, to the level of that spine.

The glottis is in front of the third cervical spine. Thence the trachea passes downwards in front of the bodies of the vertebræ, inclining somewhat to the right, the bifurcation of the trachea being in front, and a little to the right of the tip of the fifth dorsal spine.

The pharynx and œsophagus intervene between the bodies of the vertebræ and the larynx and trachea; consequently, when the spinal column is removed, the œsophagus conceals the trachea from view. The œsophagus, like the trachea, bears somewhat to the right during its descent. The aorta and the œsophagus lie side by side in front of the bodies of the vertebræ, the latter lying upon their right half, the former upon their left half. The œsophagus crosses in front of the aorta, anterior to the eighth dorsal spine, and it penetrates the diaphragm, and enters the cardiac orifice of the stomach to the left of the ninth and tenth dorsal spine.

PL. XIII.



The heart and great vessels, from the top of the arch of the aorta to the lower edge of the left ventricle, usually occupy the space extending downwards from the third to the ninth dorsal spine. The third dorsal spine indicates the top of the arch of the aorta; the fourth, the top of the pulmonary artery. The mitral valve is situated in front of the space between the sixth and eighth spines, with a bearing to the left. The apex of the left ventricle is on a level with, but considerably to the left of, the eighth dorsal spine.

The descending aorta lies in front of the left half of the bodies of the vertebræ. The spring of the cœliac axis is indicated by the twelfth dorsal spine, the origin of each renal artery by the first lumbar spine, and the bifurcation of the aorta by the fourth lumbar spine.

The ascending vena cava, at its commencement in the confluence of the iliac veins, is on a line with the fourth lumbar spine. The vein pierces the diaphragm in front of the ninth, and empties itself into the right auricle on a level with the seventh dorsal spine.

The lower boundary of the diaphragm, where the pleura is reflected upon it from the ribs, is situated to each side of the twelfth dorsal spine. This is the limit to which the lower boundary of the lungs can descend during the deepest possible inspiration.

The right summit of the diaphragm, which corresponds with the convex upper surface of the liver, is usually above the eighth dorsal spine; while the left summit, which invests the upper convexity of the stomach, is below that spine.

When the liver is large and the stomach empty, the level of the left summit of the diaphragm is much lower in relation to that of the right, than when the stomach is much distended, in which case the diaphragm sometimes encroaches upwards on the chest as much on the left side as the right.

The convex upper surface of the liver corresponds, as I have just said, with the right summit of the diaphragm, being on a level with the space above the eighth dorsal spine. The liver comes in contact with the surface posteriorly just below the base of the right lung, on a level usually with the tenth dorsal spine. The vena porta enters and the hepatic duct emerges from the liver in Plate XIV., on a level with the space between the last dorsal and first lumbar vertebræ. Below this point the kidneys and the intestines are interposed between the liver and the parietes.

The cardiac orifice of the stomach is situated to the left of the ninth and tenth dorsal spines. A small portion of the stomach is usually, as in Plate XIII. S, immediately subjacent to the surface, between the base of the left lung and the suprarenal capsule. This exposed portion of the stomach (S) is, however, covered by lung, when the left base descends, so as to be interposed between the surface and the suprarenal capsule. The pylorus (see Plate IV.) crosses from left to right, in front of the portal vein, on a level with, or below, the twelfth dorsal spine; and, in Plate XIV., is hidden, just before it empties itself into the duodenum (D), by the vena porta, and vena cava.

The upper edge of the spleen is usually on a level with the ninth, its lower edge, with the twelfth dorsal spine.

The twelfth dorsal and first lumbar spines indicate the position of various parts and organs of importance. I advise the careful study of the relative position of these parts in Plates XIV., XII. and XIII., and, by way of comparison, in Plates IV. to VII. (front views), and IX., XI. (side views). The cœliac axis and the upper mesenteric artery arise in front of the body of the first lumbar vertebra, and are on a level with the last dorsal spine. The renal arteries arise in front of the body of the second and the spine of the first lumbar vertebra. Owing to the attachment of the aorta to the spinal column by means of its branches successively distributed to the intercostal spaces and abdominal parietes, all the branches of the abdominal aorta have a fixed position at their origin, being uninfluenced either by the movements of respiration, or by the changes in position and size of the abdominal organs.

The solar plexus and the origin of the thoracic duct, which also occupy the space indicated by the last dorsal and first lumbar spines, are fixed in position, like the arteries to which they are contiguous.

The pancreas, where it passes from the spleen to the front of the aorta, is on a level with the space between the eleventh dorsal and first lumbar spines. Where it crosses in front of the aorta and vena cava, occupying the inner circuit of the duodenum, it is indicated by the space between the twelfth dorsal and second lumbar spines. The pancreatic duct enters the duodenum with the biliary duct on a level with the lower edge of the first lumbar spine.

The duodenum, viewed posteriorly, as it takes its circuit round the head of the pancreas, comes into view in Plate XIV., on a line with the space between the last dorsal and first lumbar spines, being there contiguous to the point at which the vena porta enters and the hepatic duct emerges from the liver. The duodenum from thence descends along the side of the ascending vena cava, curves to the left, and crosses before the great vessels in front of the second and third lumbar spines. Thence it ascends to the left of the aorta, and disappears among the mass of intestines. The portion of pancreas contiguous to the spleen is much more subject to the movements of respiration, and to the constantly varying size and position of the stomach and intestines, than the portion of pancreas surrounded by the duodenum. The duodenum and adjoining pancreas, being loosely adherent, ascend slightly during expiration and descend during inspiration, and are lowered and spread out more widely when the duodenum is itself distended.

The upper edge of the right kidney is usually on a line with the space between the eleventh and twelfth dorsal spines, its lower edge being to the right of the third lumbar spine. The left kidney is usually lower than the right. This was the case in eight of the thirteen bodies included in the subjoined table, while the right kidney was lower than the left in three, and the kidneys were on the same level in one of these bodies. The pelvis of each kidney is usually on a level with the first lumbar spine.

Each suprarenal capsule is a degree higher than the upper edge of the kidney to which it is attached.

The liver, the spleen and adjoining portion of the pancreas, the kidneys and suprarenal capsules, and the great and small intestines, are all pushed downwards, by the descent of the diaphragm, during inspiration, and are raised, pushing before them the diaphragm, by the contraction of the abdominal muscles, during each expiration; and all these organs, whether solid or hollow, vary in size, as they contain more or less blood, or more or less liquid and gaseous contents, with the constant effect of being displaced by, and displacing each other.

The origin of the vessels supplying each of these organs forms a point of attachment in connection with which their movements are modified. Thus the cœliac axis serves as a fixed point of attachment for the pancreas, spleen, liver, and stomach. The mesenteric arteries are points of attachment for the intestines, and the renal arteries, for the kidneys.

The following Table presents at one view the position of various parts and organs in relation to the spines of the vertebra, in thirteen bodies dissected by myself from the dorsum. In the first five subjects, the face and body were embedded in Plaster-of-Paris on the plan described in the explanation of Plate XIII.

EXPLANATION OF PLATE XIII.

In the bodies from which this Plate and Plates XIV. and XV. were taken, I first exposed the ribs, vertebræ, and superficial internal organs, as in Plate XII. After taking a tracing of the parts so exposed, I embedded the face, neck, chest, and pelvis, and the ribs and abdominal parietes, in Plaster-of-Paris. The ribs were then sawn across, and the spinal column was carefully removed. By adopting this plan, the internal organs kept their original position, and a solid prop was afforded to the ribs and abdominal parietes, which otherwise would have yielded outwards when deprived of their natural support. I advise the adoption of this plan to any one who may be induced to make for himself the very instructive series of dissections figured in these four plates representing the back view of the internal organs.

The subject from which Plate XIII. was taken was a man said to be seventy-six years of age, but muscular, and of broad, square set proportions. He died of suffocative catarrh. His internal organs were apparently healthy, the lungs being free from adhesions. The arteria innominata, the trachea and right bronchus, and the right pulmonary artery, which have been brought into view by drawing aside the inner edge of the right lung, were figured, not from this, but from another healthy body.

The whole spinal column, with the adjoining portion of the ribs, have been removed, and the organs immediately subjacent brought into view.

In the neck—The posterior wall of the pharynx, the extremities of the os hyoides, the thyroid bodies, the great vessels and the sternocleido mastoid, the omo-hyoid, and the levatores scapulæ, are exposed.

In the chest—The œsophagus, the thoracic aorta, and the lungs *in situ*, are seen. The pericardium, and the entrance into it of the inferior vena cava, and the organs spoken of above, have been brought partially into view by the withdrawal of the inner edge of the right lung.

In the abdomen—The great vessels, the suprarenal capsules, kidneys and ureters, the ascending colon, and the sigmoid flexures are displayed; and above the other organs, just beneath the diaphragm, a portion of the liver, spleen (Sp.), and stomach (S) are revealed.

(Reduced from $35\frac{1}{4}$ to $18\frac{3}{4}$ inches.)

TABULAR VIEW.

The following Parts and Organs were respectively on a level with the spine of the vertebra initialized in the annexed columns. Thus, in No. 1, see Plate XIV., the base of the right lung is on a level with the lower edge of the spine of the eleventh dorsal vertebra,—the summit of the upper lobe is as high as the space between the last cervical and first dorsal spines.

	1. Plate XIV.	2. Plate XV.	3. Plate XIII.	4. Plate XII.	5. Adult Male.	6. Adult Male.	7. Adult Male Right Pneumonia.	8. Adult Male.	9. Adult Male.	10. Adult Male. Lungs adherent.	11. Adult Male.	12. Adult Male.	13. Adult Male.
Summit of upper lobe	bel. 7 C	bel. 7 C	bel. 7 C	bel. 7 C	bel. 7 C	bel. 7 C	bel. 7 C	bel. 7 C	bel. 7 C	bel. 7 C	bel. 7 C		7 C
Summit of lower lobe :—													
right	..	4 D	3 D	bel. 2 D	bel. 2 D	bel. 4 D	..	..	..	..	ab. 4 D	bel. 4 D	3 D
left	3 D	bel. 2 D	2 D	ab. 3 D	..	2 D	bel. 2 D	..	..	..	ab. 4 D	bel. 3 D	
Base of lower lobe :—													
right	11 D	bel.10 D	bel. 10 D	10 D	11 D	ab 10 D	bet. 11 & 12 D	bel. 9 D	10 D	ab. 12 D	ab. 10 D	11 D	9 D
left	11 D	bel.10 D	ab. 11 D	10 D	..	ab. 11 D	bel. 10 D	ab. 10 D	10 D	bel. 11 D	10 D	bel. 10 D	ab. 10 D
Larynx (vocal chords)	bel. 4 C	bel. 4 C	bel. 4 C	4 C	ab. 5 D	5 C	..	..	..	..			
Bifurcation of trachea, lower edge	ab. 5 D	5 D	ab. 5 D	ab. 4 D	4 D	bel. 4 D	..	ab. 5 D	ab. 5 D	bel. 5 D	bel. 4 D	ab. 5 D	ab. 5 D
Top of arch of aorta	bel. 3 D	bel. 3 D	bel. 2 D	ab. 3 D	ab. 3 D	bel. 3 D	..	ab. 3 D	ab. 3 D	..	ab. 3 D	ab. 3 D	bel. 3 D
Top of right pulmonary artery	4 D	4 D	bel. 3 D	..	ab. 4 D	..	..	ab. 4 D	..	..	ab. 4 D		
Left auricle :—													
upper boundary	bel. 5 D	ab. 5 D	bel. 5 D	..	5 D	..	..	bel. 5 D					
lower boundary	bel. 7 D	ab. 7 D	bel. 7 D	..	7 D	..	..	bel. 7 D					
Ascending vena cava :—													
entrance into right auricle	7 D	ab. 7 D	..	..	7 D	bel. 6 D	..	7 D	..	.	ab. 7 D.		
passage through diaphragm	9 D	bel. 8 D	9 D	..	8 D	bel. 7 D	..	bel. 8 D					
Lower boundary of left ventricle	ab. 9 D	bel. 8 D.	9 D	ab. 9 D	ab. 9 D	bel. 7 D	..	bel. 8 D	bel. 8 D	..	bel. 8 D	8 D	bel. 8 D
Aortic valve	..	..	..	..	..	..	..	..	bel. 5 D				
Mitral valve :—													
upper edge	..	..	..	..	..	..	..	..	ab. 6 D				
lower edge	..	..	..	..	..	..	..	..	ab. 8 D				
Summit of right convexity of diaphragm (liver)	ab. 8 D	ab. 7 D	8 D	ab. 8 D	ab. 8 D	ab. 7 D	..	bel. 7 D	ab. 8 D	bel. 9 D	ab. 8 D	ab. 8 D	ab. 8 D
Summit of left convexity of diaphragm (stomach)	ab. 9 D	bel. 7 D	ab. 9 D	8 D	bel. 8 D	7 D	..	8 D	ab. 8 D	ab. 10 D	8 D	ab. 8 D	8 D
Spleen :—													
upper edge	9 D	8 D	9 D	ab. 10 D	9 D	7 D	..	..	9 D	ab. 10 D			
lower edge	bel. 12 D	12 D	11 D	12 D	12 D	10 D	..	..	ab. 12 D	ab. 2 L			
Pancreas, duodenal head :—													
upper edge	12 D	..	12 D	..	ab. 12 D	ab. 11 D							
lower edge	2 L	..	2 L	..	ab. 2 L								
Entrance of portal vein into, and exit of duct from liver	ab. L	..	bel. 11 D	..	10 D	11 D							
Duodenum :—													
entrance of biliary duct into	bel. 1 L	..	ab. 1 L	..	bel. 12 D	bel. 1 L							
lower edge of	bel. 3 L	..	3 L	..	ab. 3 L	bel. 3 L							
Right kidney :—													
upper edge	12 D	..	ab. 11 D	..	..	..	12 D	..	11 D	ab. 12 D	..	..	bel. 11 D
lower edge	3 L	bel. 3 L	3 L	3 L	..	ab. 3 L	3 L	3 L	ab. 3 L	bel. 3 L	2 L	2 L	3 L
Left kidney :—													
upper edge	12 D	..	11 D	..	ab. 11 D	bel. 24 D	ab. 12 D	..	ab. 12 D	11 D	..	..	11 D
lower edge	3 L	ab. 3 L	bel. 3 L	2 L	..		ab. 3 L	ab. 3 L	3 L	3 L	ab. 3 L	ab. 2 L	ab. 3 L
Œsophagus enters stomach at cardiac orifice	bet. 9 & 10 D	9 D	bet. 9 & 10 D	bet. 9 & 10 D	9 D	bet. 9 & 10 D							

EXPLANATION OF THE ABOVE TABLE.

C—signifies The spine of a cervical vertebra.
D— „ The spine of a dorsal vertebra.
L— „ The spine of a lumbar vertebra.

When the letter C, D, or L appears alone, the part in question is situated on a level with the lower end of the spine initialized.

When "bel." precedes the letter C, D, or L, the part is just below, and when "ab." precedes the letter C, D, or L, the part is just above the lower end of the spine indicated. Where "bet. 9 & 10, D" is inserted, the object named is on a level with the space between the spines of the ninth and tenth dorsal vertebræ.

Nos. 1, 2, 3, & 4, correspond with the Plates now under review.

No. 8 was figured in the Medical Gazette for 1848.

Nos. 9 & 10 were figured in the Prov. Med. Trans. Vol. 12. The remainder have not been published.

THE LARYNX, TRACHEA, AND LUNGS.

(*See columns* 3—10, 25—33.)

By comparing Plates XIV. and XV. with Plates VII. and XI. the position of the larynx and trachea, and their relation to the nostrils and fauces, may be studied. As may be seen in Plate XI., the posterior fauces form an open channel for the passage of respired air between the nostrils and the larynx. This channel is formed in front by the soft palate, the tongue, and the epiglottis, at the sides by the tonsils, and behind by the bones of the first four vertebræ, the posterior wall of the fauces and pharynx being interposed. This channel is only closed during the act of deglutition, and when the tongue is voluntarily pressed backwards against the soft palate and posterior wall of the fauces. The tongue is evidently prevented from falling back upon the posterior wall of the fauces, so as to close the respiratory channel, by means of the arched os-hyoides, the pillars of which rest on the vertebræ, and to a less extent by the forward support given to the tongue by its muscles arising from the lower jaw. This respiratory channel, conveying air from the nostrils to the larynx, extends downwards from the base of the cranium in front of the bodies of the first four vertebræ.

When this respiratory channel is much narrowed by enlargement of the tonsils, the patient breathes through the open mouth, especially during sleep.

When the tonsils are enlarged so as materially to narrow the respiratory channel, loud hissing breath sounds are excited, audible in the open air, and over the front and back of the neck.

During the act of deglutition, the morsel of food, and the back of the tongue press the soft palate backwards against the posterior fauces, so as to close the posterior nares. At the same time the larynx is drawn forwards and upwards, and what was formerly a part of the channel for breathing becomes now the channel for food.

In Plate XIII. the larynx, and the trachea, all but its right edge, are hidden by the pharynx and œsophagus. In Plate XIV., the

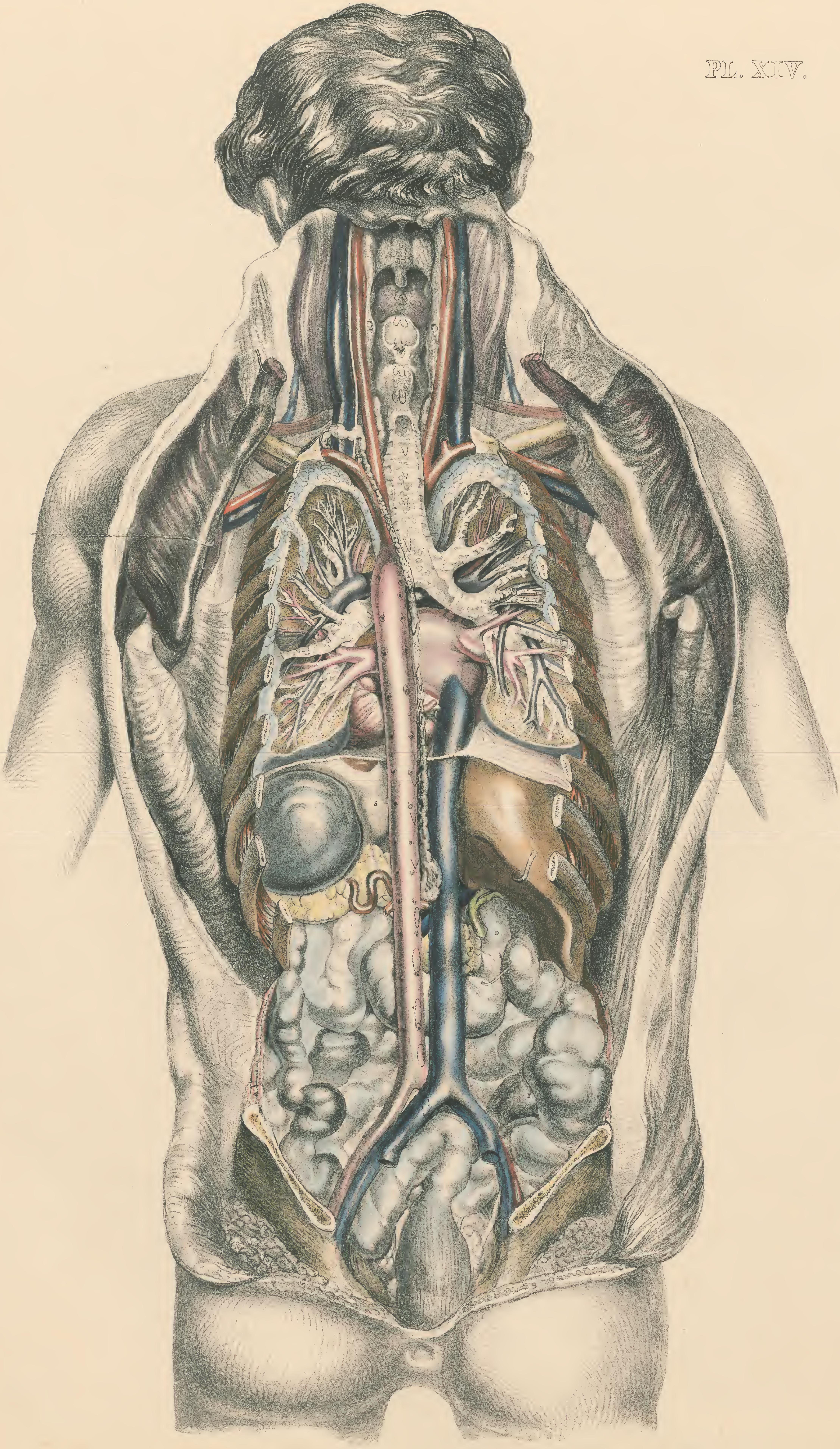
posterior surface of the larynx, and the trachea with its bifurcation are exposed. In Plate XV., the interior of the larynx is brought into view by cutting away a portion of the cricoid, and by separating the arytenoid cartilages.

The larynx, extending from the top of the epiglottis to the lower end of the cricoid cartilage, is situated (the posterior wall of the pharynx being interposed) in front of the bodies of the cervical vertebræ, from the third to the sixth, in Plates XIV., VII., and IX. In Plates X. and XI., the larynx is higher by the breadth of the body of a vertebra, since it extends in them from the second down to the fifth dorsal vertebra. The larynx, in fact, has no fixed position, but moves downwards with each inspiration, upwards with each expiration. In the robust, (as in Plates XIV. and IX.), and still more in those affected with emphysema, it is lower than in the flat-chested (as in Plates X. and XI.) and the phthisical. The trachea, down to its bifurcation, presents the same respiratory movements, and the same varieties in position as the larynx.

The top of the cricoid, and the arytenoid cartilages occupy the two anterior thirds of the hollow of the thyroid cartilage: they are consequently sustained forwards, so as to be free from contact with the posterior wall of the pharynx. The thyroid cartilage, in fact, acts as a bridge to protect the other cartilages from pressure, its posterior edges and cornua resting, with a long, firm support, upon the bodies of the third, fourth, and fifth cervical vertebræ, the posterior wall of the pharynx being interposed: the result is, that the arytenoid cartilages move in a free space, so as to widen the glottis during inspiration, and to stretch and approximate the vocal chords during the acts of speaking, coughing, and laughing. These sounds would, indeed, be stifled in their production, if the vocal chords were damped during their action by the contact of the arytenoid cartilages with the posterior wall of the pharynx.

The arch formed by the os-hyoides, acts in like manner as a bridge, to prevent the epiglottis from being forced backwards.

PL. XIV.



THE AORTA AND ITS ANEURISMS.

The aorta, from its origin to its bifurcation, is surrounded by important organs, and protected in front by the walls of the chest and abdomen, and behind by the spinal column. Its anatomical relations change at each successive part of its course. When the aorta is affected with aneurism, there is no symptom of the disease, and rarely any sign, unless the pulsating tumour presents at the surface, or presses on the surrounding organs so as to interfere with their function. The close study of the relative anatomy of the aorta is consequently the true, and, indeed, only clue to the diagnosis of aneurisms of the aorta. I shall here, therefore, give an analysis of the anatomical relations, signs, and symptoms of each aortic aneurism, after describing the relative anatomy of the corresponding portion of the aorta. This analysis, as I have further detailed in the appendix of tables, is derived from the examination of the histories of 584 cases of aortic aneurism, obtained from various sources, and of 296 specimens examined in Museums, and to which no history was attached. The Museum specimens are never referred to unless they are specially mentioned.

Plates XIII. and XIV. exhibit the aorta in its course from the source of the left subclavian to its bifurcation. The arch of the aorta is exposed in Plate XV. In studying the aorta in these plates, I advise that Plate XII. be kept in view, so that the aorta may be figured on it as it were by the mind's eye, in its relation to the spinal column. The aorta may, at the same time, be observed with advantage in Plates IV. to VII. (front views), and Plates IX. and XI. (side views).

The ascending aorta, the arch, and the upper portion of the descending aorta, vary in position in accordance with the movements of respiration. The position of the descending aorta from the point at which it comes in contact with the spinal column, down to its bifurcation, is fixed, owing to its attachment to the spine by the intercostal and other parietal branches.

The ascending aorta and arch, the heart itself, the trachea and bronchi, and the pulmonary vessels, are all lowered during each inspiration by the descent of the diaphragm, and they are all elevated by the ascent of the diaphragm.

The descent during inspiration of the ascending aorta is much greater than that of the upper portion of the descending aorta, which is restrained by its attachment to the spinal column. The play of the transverse is less than that of the ascending, and greater than that of the descending aorta. During inspiration, the ascending aorta is somewhat straightened as well as lowered, and the curve of the arch is rendered more acute.

THE SINUSES OF VALSALVA.

The first portion of the ascending aorta, including the sigmoid valves and sinuses, is imbedded in the body of the heart, being surrounded by its various walls, cavities, and vessels. The right ventricle and the auricular portion of the right auricle are in front of the aorta, the pulmonary artery is on its right side, the right auricle and the vena cava are on its left, and the left auricle and the right pulmonary artery are behind it.

The aortic valves are usually on a level with the top of the body of the eighth and the spine of the sixth dorsal vertebræ behind, and with the middle of the sternum on a line with its junction to the third costal cartilages in front; so that if a rifle bullet went in at one of those points, straight through the body, and out at the other, it would tear its way through the aortic valves.

Mr. Thurnam, in his important paper on aneurisms, following the descriptions of Valsalva Senac and Portal, erroneously designates the sinuses within which the coronary arteries arise, the "right and left anterior sinuses," while the intermediate sinus he terms "posterior." The fact is, as may be readily ascertained when the heart is *in situ*, the sinus that gives origin to the left coronary artery is situated not anteriorly, but posteriorly. That valve and the intercoronary valve, indeed, meet at the centre of the posterior wall of the aorta. I shall here, therefore, to avoid ambiguity, return to Bizot's term of "intercoronary," rejected by Mr. Thurnam, and shall name the two other valves and sinuses respectively, the right and left coronary.

The aneurisms of the sinuses of Valsalva, and of the ascending aorta immediately above and between the valves, are in their very nature sacculated. The right coronary sinus is the most, the left coronary the least, frequently affected. I conceive that one reason for this is the fact, that at the beginning of the diastole the recoil of the current of blood from the trunk of the aorta back upon the sinuses takes place chiefly on the right anterior aspect of the vessel. The aneurisms of the sinuses in about a moiety of the cases compress the pulmonary artery, and the adjoining part of the right ventricle, so as to impede the exit of blood from the ventricle, and in many instances to cause regurgitation through the pulmonic valves. They cause pressure of the auricular portion of the right auricle in nearly one-half of the cases, and in a small proportion of the cases they compress the right and left auricles conjointly, the left ventricle, the descending vena cava, the right lung, and the left lung.

The aneurisms of the sinuses ruptured in 80 per cent. of the cases; in 45 per cent. into the pericardium, 13·5 per cent. into the pulmonary artery, 8·5 per cent. into the right auricle, 5 per cent. into the right ventricle, and 5 per cent. into the left ventricle.

The heart was stated to be enlarged in 29 per cent. of the cases, and the pericardium was adherent in 7 per cent.

Murmur was observed in 34·5 per cent. of the cases; but as in more than half the signs were not observed, the actual proportion in which murmur was present was undoubtedly much greater. The great frequency of murmur in aneurisms of the sinuses is due to the regurgitation which so often takes place through the pulmonic valves, as well as through the aortic valves themselves. Pulsating tumour was present in 7 per cent. of the cases, one-half being to the right, one-half to the left of the sternum.

Dyspnœa was observed in 38 per cent. of the cases, cough in 24 per cent., pain in 21 per cent. 38 per cent. appeared to be in perfect health up to the time of the fatal attack. The small proportion of cases with symptoms of disease, and the large proportion apparently healthy, are due to the non-existence in many cases of pressure on important organs, and to the early period at which rupture takes place into the adjoining pericardium. It will be observed throughout, that the greater the proportion of ruptures in any group of aneurisms of the aorta, the smaller is the proportion of instances in which the disease is indicated by symptoms during life, and *vice versâ*.

THE ASCENDING AORTA ABOVE THE SINUSES OF VALSALVA.

The ascending aorta, after it clears the heart, rests upon the right pulmonary artery and the left side of the trachea. The superior vena cava is on its right side, the pulmonary artery and a portion of the left lung are on its left. It is separated from the lower half of the upper third of the sternum by the approximated edges of both lungs; but when those edges have shrunk to either side, it is immediately behind the sternum, the pericardium being interposed.

Aneurisms of the ascending aorta above the sinuses are sacculated in about 51 per cent., and present simple dilatation of the artery in about 37 per cent. They originated in the anterior aspect of the aorta in 15, in the right in 46, and in the left in only 8 instances, including the Museum specimens. This great predominance to the right is evidently due to the direction of the current of blood, which being propelled forwards and from left to right by the left ventricle, impinges on the right anterior wall of the ascending aorta, so as to dilate the vessel at that part. In unison with the direction of the aneurism anteriorly and to the right, we find that the sac compressed the right lung in 34 instances, the left lung in 10; the right bronchus in 6 instances, the left in 1; that the ribs, cartilages, and sternum were eroded to a greater or less degree—to the right in 26 cases, to the left in 6; and that a pulsating tumour presented externally to the right in 20 cases, to the left in 8. The aneurism made pressure on the pulmonary artery in 7 instances, on the descending vena cava in 16, on the trachea in 9, and on the œsophagus in 9.

The aneurisms ruptured in 57 per cent. of the cases; externally in 8, into the pericardium in 22, the pulmonary artery in 4, the right auricle in 1, the descending vena cava in 5, the trachea in 1, the right bronchus in 3, the right lung in 5, the left lung in 2, the right pleura in 2, and the left pleura in 4. The frequency of adhesions of the right pleura, owing to the pressure of the tumour on the right side, appears to account for the small number of ruptures into the right pleura, and the comparatively large number into the left.

Murmur was observed in 23 per cent. of the cases. Deficient breathing over the right side of the chest, though it must have existed in many of the cases, was noticed in but 7. A sharp diastolic shock or second impulse was felt over the tumour in several cases. Fourteen per cent. died suddenly, and 11 per cent. were apparently in health up to the time of the fatal attack. Dyspnœa was noticed in 51 per cent., orthopnœa in 18, cough in 36, raucous voice or stridor in 4, and dysphagia in 2 per cent. Pain was felt in 40 per cent.; in the chest 29, in the neck and shoulders in 10, and in the right arm in 2.

THE TRANSVERSE AORTA.

The transverse aorta, as it arches over the left bronchus, passes backwards with only a slight obliquity to the left. In the dead body just opened, when the vessels are flaccid, as in Plate V., the transverse aorta does not look like an arch; but when it is injected, as in Plate VI., it assumes somewhat of an arched form. If however we look at the side view, Plate IX., we at once see how completely the ascending transverse and descending aorta form an arch, stretching over the left bronchus and the right pulmonary artery. The left recurrent nerve, curving backwards and upwards around the arch, close to the subclavian artery, is figured in Plate XV. The transverse aorta almost touches the œsophagus after giving off the left subclavian.

Aneurisms of the transverse aorta are sacculated in the proportion of 61 per cent., and present simple dilatation of the artery in 20 per cent. The sac communicated with the aorta by an aperture in its

EXPLANATION OF PLATE XIV.

This drawing was obtained from the body of an adult who died of delirium tremens.

In the neck, the pharynx has been removed, exposing—the posterior nares, the soft palate and uvula, the tongue, the epiglottis, and the arytenoid and cricoid cartilages.

In the thorax, the œsophagus has been removed, and the lungs have been dissected, exposing—the trachea, the bronchi, and the pulmonary arteries and veins; the thoracic aorta; the right and left auricles; and the left ventricle.

In the abdomen, the kidneys have been removed, while the posterior part of the pelvis

has been sawn away, exposing—the liver, spleen, and pancreas (P); the stomach (S); the duodenum (D); the biliary and pancreatic ducts, and the portal vein, which were figured from another body; the sigmoid flexure and head of the colon, and the end of the ileum (I); the small intestines; the rectum, and bladder; and the great vessels.

The thoracic duct, which is too large, was drawn from a preparation presented by Mr. Lane to the Museum of St. Mary's Hospital, from Cruikshank's work on the Absorbents and Bourgery's plates. (Reduced from 36 inches to 19).

upper aspect in 19, in its posterior or more properly right aspect in 41, and in its anterior or more properly left aspect in 19 instances, including Museum specimens.

Pulsating tumour or fulness was present in 44 per cent. of the cases. In 19 per cent. the tumour was central, in 12·5 it appeared to the right of the sternum, and in 12·5 to the left. The tumour in these cases appeared either at or above the manubrium, while it usually presented just below the manubrium in cases of aneurism of the ascending aorta. Murmur was detected in 15 per cent. Breathing was deficient over the right side of the chest in 6 per cent., over the left in 4.

Dyspnœa was present in 71 per cent., orthopnœa in 20, cough in 57·5, hæmoptysis in 19 per cent. The voice or cough was raucous or whispering, or inspiration was stridulous in 47·5 per cent. This large proportion of cases with laryngeal symptoms is due to the frequency of pressure on the trachea and on the recurrent nerve. Dysphagia existed in 31 per cent. The pulse was weaker at one wrist than the other in 26 per cent., the left pulse being the most frequently affected. Pain was complained of in 36 per cent., in the chest in 21, the left upper extremity in 8, the right in 4 per cent.

ASCENDING AND TRANSVERSE AORTA CONJOINTLY.

To avoid confusion I have separated aneurisms of the ascending and transverse portions of the arch of the aorta conjointly from those affecting either of those portions singly. Although, as might have been foreseen, these aneurisms are allied partly to those of the ascending, partly to those of the transverse aorta, yet they form a natural group, differing in some essential points from either of them. While aneurisms of the ascending aorta and of the transverse aorta singly are usually sacculated, those of the ascending and transverse aorta conjointly are sacculated in only 31 per cent., the artery being dilated in as many as 85 per cent. The bearing of the conjoint aneurism is usually to the right—in this respect resembling aneurism of the ascending aorta singly. Thus the sternum and ribs were eroded to the right in 13 per cent., to the left in 4, at the centre in 7. Pulsating tumour appeared externally to the right of the sternum in 17 per cent., to the left in 4, and in the centre of the chest in 10. The right lung was compressed in 17 per cent., the left lung in 6. The descending vena cava was compressed in 10 out of 44 specimens observed in the various Museums. A smaller proportion of the cases resemble aneurism of the transverse aorta, the trachea being compressed in 33 per cent., the œsophagus in 9. Of the specimens observed in Museums there was obstruction of the arteria innominata by clot in 2, the left carotid in 1, the innominata and left carotid in 1. The conjoint aneurisms ruptured in 37 per cent. of the cases; into the pericardium in 10, the pulmonary artery in 1·5, the vena cava in 4, the trachea in 4, the right pleura in 3, and the left pleura in 1·5 per cent.

While of the conjoint aneurisms a smaller number rupture than of those of the ascending aorta alone, a larger number present formidable symptoms during life. There was pulsating tumour in 30 per cent., murmur was noticed in 22 per cent. Dyspnœa was present in 74 per cent., orthopnœa in 21·5, cough in 47, hæmoptysis in 10, stridulous breathing or affection of voice in 17, dysphagia in 21·5. Pain was present in 46 per cent.; in the chest in 30 per cent., the right side of it in 11, the left in 7; in the back in 10; the upper extremities (one or both) in 18, the right in 6, the left in 3; in the neck in 4 per cent. The head and neck were swollen in 14 per cent.; the right pulse was weak or imperceptible in 6 per cent., the left pulse in 3.

THE DESCENDING PORTION OF THE ARCH.

The descending portion of the arch lies at first upon the left lung and the œsophagus. It gradually separates these from each other, and at last rests fixedly on the left half of the body of the fifth or sixth dorsal vertebra, where the œsophagus is situated to the right of the aorta, the left lung to its left. The left bronchus and the right pulmonary artery lie in front of the descending aorta, as they pass between it and the ascending aorta. The thoracic duct is immediately behind the meeting point of the descending aorta and the œsophagus.

The aneurisms of the descending portion of the arch are sacculated in 81 per cent., and present general dilatation of vessel in only 8 per cent. The proportions were 62·5 per cent. and 21 per cent. in the specimens observed in Museums. The direction of the aneurism is usually backwards and to the left. The vertebræ were eroded in 42 per cent., the left ribs anteriorly in 4. The tumour made pressure upon the trachea in 12·5 per cent., the left bronchus in 37·5, the œsophagus in 31, the left lung in 48, the right lung in 6 per cent. The sac ruptured in 75 per cent. of the cases; into the trachea in 4 per cent., the left bronchus in 16·5, the left lung in 4, the left pleura in 23, the right lung in 6, and the right pleura in 12·5 per cent. Pulsating tumour appeared externally in 6 per cent.; murmur was heard in 23 per cent. Breathing was deficient over the left side of the chest in 19 per cent. Dyspnœa was noticed in 50 per cent., cough in 46; the respiration was stridulous, or the voice was affected in 25 per cent. Dysphagia existed in 33 per cent. Pain was present in 62·5 per cent. The pain was seated in the back in 27, in the chest in 52 per cent.; of these it radiated around the left side from the spine in 21 per cent. The pain in about 25 per cent. was of two kinds, constant in the back, and radiating in the left intercostal spaces. Pain is a more frequent and characteristic symptom in aneurisms of the descending portion of the arch, than in those of the ascending and transverse portions. The anatomical reason of this is obvious. The anterior portion of the arch moves freely, and its aneurism pushes aside the par vagum and sympathetic, which yield before the sac. The descending part of the arch is comparatively fixed by the intercostal arteries arising from it. When the sac expands, it erodes the vertebræ and compresses the intercostal nerves backwards against the bone, so as to excite fixed and radiating pain. Out of 21 cases in which the vertebræ were eroded, fixed pain in the back and radiating pain in the side were both present in 10; in 1 other there was pain of the back, and in 5 others of the side or chest chiefly radiating; in 3 only was there no pain. On the other hand, out of 27 cases, in which the vertebræ were not eroded, in 12 only was pain noticed, and in but 2 of them was there both fixed and radiating pain.

THE DESCENDING THORACIC AORTA BELOW THE ARCH.

The descending thoracic aorta, from the sixth dorsal vertebra to the twelfth, is situated in front of the left half of the bodies of the vertebræ. The left lung down to its base is seated on the left side of the aorta, and the œsophagus descends along its right side down to the body of the tenth dorsal vertebra, where the œsophagus crosses in front of the artery to escape through the diaphragm. The ascending vena cava lies more or less near to the right side of the aorta, from the tenth dorsal vertebra down to the bifurcation. Anteriorly to the descending aorta are situated, first the left bronchus, and then in succession the right pulmonary artery, the posterior surface of the pericardium, the œsophagus, and, until it enters the abdomen, the crura of the diaphragm. The aorta emerges into the abdomen between the crura of the diaphragm, in front of the body of the first lumbar vertebra.

Aneurisms of the descending thoracic aorta, below the arch, are sacculated in 35 per cent. of the cases; present general dilatation in 28, and are undescribed in 37. The proportion were respectively 58, 50, and 4 per cent. in the specimens observed in Museums. The aneurism usually lay along the left side of the spinal column, and caused erosion of the vertebræ in 74 per cent. The sac displaced the œsophagus in 8 of the 24 specimens observed in Museums. The left, and, though much less frequently, the right lung, were compressed by the aneurism in a large proportion of the cases. The sac burst, in 65 per cent. of the cases; into the trachea in 2, the left lung in 13, the left pleura in 26, the right lung in 6·5, and the right pleura in 13 per cent.

Pulsating tumour presented externally in 26 per cent.; murmur was detected in only 4 per cent; dyspnœa existed in 26 per cent.; orthopnœa in 4; cough in 24; dysphagia in 9. Pain was complained of in 67 per cent. The pain was felt in the back in 43·5, in the chest in 29, in the abdomen in 13, and the left lumbar region in 19·5 per cent. Of the 34 cases in which the vertebræ were eroded, pain was present in 26, not noticed in 8. Of the 12 cases in which the vertebræ were not eroded, pain was present in only 4, not noticed in 8. In 31 of the cases the upper portion of the artery was affected; of these 11 complained of pain in the chest, 5 in the loins, and 2 in the abdomen. In 15 of the cases, the lower portion of the artery was affected; of these, 3 complained of pain in the chest, 4 in the loins, and 4 in the abdomen. In several of the cases, owing to the displacement forwards of the heart by the tumour, violent palpitation was complained of, leading to the erroneous diagnosis of hypertrophy of the heart.

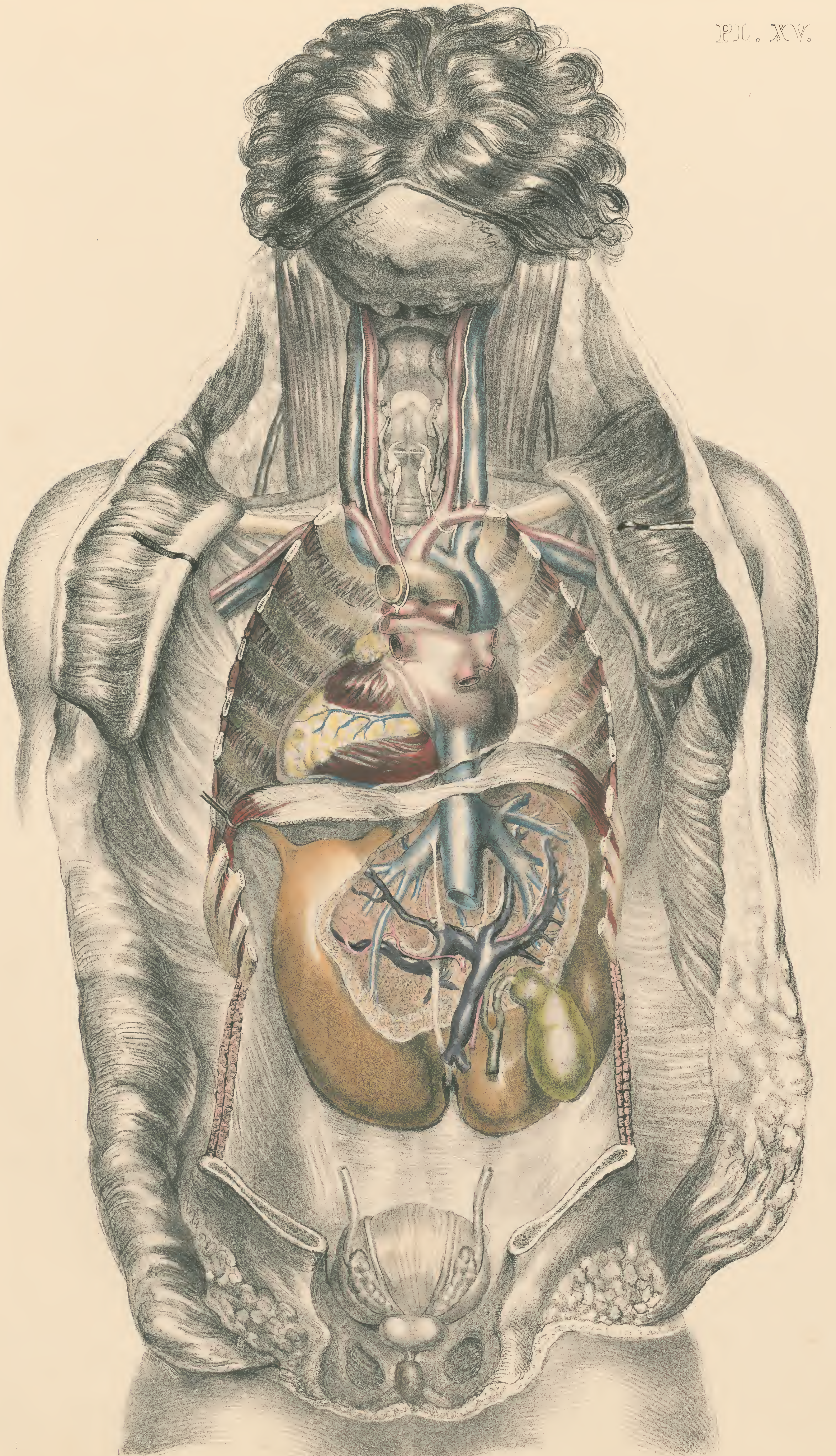
THE ABDOMINAL AORTA AT THE CŒLIAC AXIS.

The abdominal aorta, from where it appears between the crura of the diaphragm, and gives origin to the cœliac axis, to its bifurcation, is attached to the left half of the bodies of the first four lumbar vertebræ. The solar plexus and the pancreas, the duodenum, and the mesentery, successively cover the aorta in front from above downwards. The vessel lies between the ascending vena cava on its right side, and the cardiac portion of the stomach, the left suprarenal capsule, and the fat and cellular tissue within the left kidney, on its left side.

Aneurisms of the abdominal aorta in the neighbourhood of the cœliac axis are sacculated in 60 per cent., present general dilatation in 10, and are undescribed in 31 per cent. The proportions were respectively 81, 13, and 6 per cent. in the specimens observed in Museums. Of 46 cases of sacculated aneurism, 22 communicated with the aorta by an aperture on its anterior aspect, and 19 on its posterior aspect. The numbers were respectively 20 and 22 in the specimens observed in Museums. In 15 of those specimens the vertebræ were eroded by the tumour; and in the whole of these 15 instances the sac sprung from the back of the aorta. The vertebræ were eroded in 55 per cent. of the cases observed during life. In one only of those cases did the aneurism spring from the front of the aorta. It is a fair inference, though it is not actually stated of quite one-half, that in nearly the whole of those cases (55 per cent.) in which the vertebræ were eroded, the sac communicated with the aorta posteriorly. The aneurism ruptured in 77 per cent. of the cases; into the peritoneal cavity in 28·5, into the mesentery in 8, into the left pleura in 9, the right pleura in 6·5; behind the peritoneum, into the left hypochondriac region in 22 per cent., into the right hypochondriac region in 4. I exclude from those rupturing behind the peritoneum 4 cases that presented enormous diffused aneurismal sacs extending down to Poupart's ligament, and lasting for months. Hemorrhage behind the peritoneum is slow and very extensive, and is never rapidly fatal. The aneurism ruptured into the duodenum in 7·5 per cent. of those specimens observed in Museums. Of the 21 cases that either ruptured behind the peritoneum into the left hypochondrium, or presented diffused false aneurism in that region, the sac communicated with the aorta posteriorly in 17, anteriorly in only 3.

Pulsating tumour was observed in 55 per cent. of the cases, presenting in the scrobiculus cordis in 20·5 per cent., in the left hypochondrium in 22, intermediately in 4, and in the right hypochondrium in 4 per cent. A tumour not pulsating was observed in the scrobiculus cordis

PL. XV.



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in 5 per cent. Murmur was observed in 25 per cent.; dyspnœa was noticed in 8 per cent.; cough in 2·5; dysphagia in 6·5; sickness in 8; dyspeptic symptoms in 15; constipation in 19 per cent.

Pain is one of the most important symptoms in cases of aneurism of the abdominal aorta. The pain, as Drs. Beattie and Law have shown, is of two kinds,—a fixed pain at or near the tumour, present in most cases, and a paroxysmal, often lancinating pain, radiating along the course or distribution of those nerves pressed on by the tumour.

I divide the 77 reported cases of aneurism of the abdominal aorta at or near the cœliac axis into two groups, in considering their relation to pain as cause and effect. The first group, which I term the *posterior eroding aneurisms*, embraces 45 cases, and includes those, amounting to 18, in which the sac springs from the back of the aorta, and those, amounting to 43, including 16 of the 18 posterior aneurisms, in which the vertebræ are eroded; in one only of the 43 does the sac arise from the front of the aorta. The second group, which I designate the *anterior non-eroding aneurisms*, embraces 32 cases, and includes those, amounting to 22, in which the sac springs from the front of the aorta, the vertebræ not being eroded, and those, amounting to 10, in which the vertebræ were not eroded, the direction of the sac not being stated. This second group does not include either the 2 posterior non-eroding aneurisms, or the 1 anterior eroding aneurism.

Of the 45 posterior eroding aneurisms, in 4 pain is not mentioned, in 28 there was fixed pain of the back or loins; in 20 of the 28, and in 4 others, there was paroxysmal often lancinating pain in the course of the nerves in the loins, testes, or lower limb, usually the left; in 5 there was pain in the epigastrium, in 6 others in the abdomen, and in 5 others in the hypogastrium.

Of the 32 anterior non-eroding aneurisms, in 9 pain is not mentioned, in 15 there was fixed pain of the back, or loins, in only 4 of the 15 was there paroxysmal pain of the loins or lower limb; in 11 there was pain in the epigastrium, in 8 others in the abdomen, and in 3 others in the hypogastrium.

We thus see that while the posterior eroding aneurisms excite paroxysmal radiating pains in the loin or limb, as well as fixed pain in the back, in a large proportion of the cases, and pain in the epigastrium in but a small proportion; the anterior non-eroding aneurisms excite paroxysmal lancinating pain in the limb in but a small proportion of the cases, and pain in the epigastrium and abdomen in a large proportion. The pathological reason is obvious. The latter aneurisms usually compress and displace only the solar plexus and other splanchnic nerves, exciting pain therein; but the former, while they compress the solar plexus to a less degree, press frequently with force on the lumbar plexus of nerves, thereby causing in many instances not only fixed pain in the back, but excruciating paroxysmal agony in the loins, the ilium, the testes, and the lower limb. In many of these cases the course of the nerves may be traced with anatomical precision by tracking the pain from its fixed origin to its final radiating distribution.

The aneurisms of the splenic, superior mesenteric, and hepatic arteries, afford a beautiful illustration of this truth in medical anatomy. I have collected 11 such cases; in 4 of them there was pain in the epigastrium, in 3 more in the abdomen, in 4 pain was not noticed. In only 1 case was there pain of the limb; when the tumour, which was as large as a child's head, caused erosion of the vertebræ.

The whole chain of aortic aneurisms illustrates the effect of the pressure of the tumour on the nerves in exciting pain. Those of the descending aorta, from the arch downwards, when they cause erosion of the vertebræ, press directly backwards on the left spinal nerves as they issue from between the vertebræ. The eroding aneurisms of the descending portion of the arch excite fixed pain in the back, and radiating pain in the upper left intercostal spaces; those of the upper part of the descending thoracic aorta induce fixed pain of the back, and radiating pain in the lower intercostal spaces; and those of the lower part of the descending thoracic aorta cause fixed pain in the back, and radiating pain in the abdominal walls and in the loins.

I have already noticed that pain is less frequent and less regular in aneurisms of the ascending and transverse portions of the arch, those portions being comparatively moveable in relation both to the surrounding parts, and to the adjoining nerves which yield before the advancing tumour, and which are rather nerves of function than of sensation. Pain is indeed excited in the par vagum and its branches, the sympathetic plexuses, and sometimes in the phrenic nerves; but the dyspnœa, the croupy voice and cough, and the frothy sputa, are the more formidable effects of the pressure on those nerves, and are more frequently caused by it than even by the direct compression of the trachea and lungs. When in these cases the tumour presses on either brachial plexus, radiating pain is felt in the corresponding arm.

Table I.—SHOWING CERTAIN ANATOMICAL CONDITIONS, SIGNS, AND SYMPTOMS, OF EACH GROUP OF AORTIC ANEURISMS.

	Sinuses of Valsalva.		Ascending Aorta.		Ascending Aorta, Dissecting Aneurism.		Transverse Aorta.		Ascending and transverse Aorta conjointly.		Descending part of Arch.		Transverse and Descending part of Arch conjointly.		Whole Arch.		Descending thoracic Aorta below Arch.		Abdominal Aorta, at Cœliac Axis.		Abdominal Aorta below Mesenteric Artery.		Branches of Abdominal Aorta.	
	Mus. Spec.	Cases.	Mus. Spec.	Cases.	Mus. Spec.	Cases.	Mus. Spec.	Cases	Mus. Spec.	Cases.	Mus. Spec.	Cases	Mus. Spec.	Cases.	Mus. Spec.	Cases.	Mus. Spec.	Cases	Mus. Spec.	Cases.	Mus. Spec.	Cases.	Mus. Spec.	Cases.
Actual number of Museum Specimens and Cases. .	29	58	41	100	3	49	40	80	42	70	24	48	5	15	18	10	25	46	54	77	8	18	7	13
Proportion per cent. of Cases of—	Per	cent.	Per	cent.	Per	cent.	Per	cent.	Per	cent.	Per	cent.	Per	cent.	Per	cent.	Per	cent.	Per	cent.	Per	cent.	Per	cent.
Rupture of aneurism	48	80	27	57	100	79·5	55	43	17	37	41·5	75	60	53	5	50	23	65	33	77	37	56	14	54
Ditto externally	..	..	1	8	..	..	2·5	6·2	2 5	7	..	..	..	..	..	10								
Ditto into pericardium	34·5	45	15	22	100	79 5	..	2·5	..	10	..	..	..	6·5	..	..	..	2·2						
Ditto pulmonary artery	10·5	13·5	5	4	..	..	..	1·3	2·5	1·5														
Ditto right auricle	..	8·5	..	1																				
Ditto right ventricle	..	5																						
Ditto left ventricle	..	5																						
Ditto vena cava descendens	..	..	5	5	..	..	..	1·3	..	4·3														
Ditto trachea	..	..	..	1	..	..	27·3	10	5	4·3		4						2·2						
Ditto right bronchus	..	..	..	3																				
Ditto right lung	3·5	1·5	..	5	..	..	2·5	..	..	..	4	6	..	..	..	..	..	6·5						
Ditto right pleura	..	..	..	2	..	..	2·5	2·5	..	3	..	12·5	..	..	..	10	..	13	..	6·5				
Ditto left bronchus	..	..	..	..	..	..	2·5	4	5	..	16 5	16·5	..	6·5	..	10	..	2						
Ditto left lung	..	..	..	2	..	..	2·5	4	2·5	..	4	4	..	..	5 5	10	..	13	..	1·3				
Ditto left pleura	..	..	..	4	..	..	2·5	5	2·5	1·5	4	23	..	26·5	..	..	7·5	26	5·5	9	12·5			
Ditto œsophagus	..	..	..	..	..	..	10	6·2	..	1·5	..	..	20	13·3	..	10	11·5	..	..	2				
Ditto behind peritoneum—left hypochondrium. .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7·5	22				
Ditto into peritoneal sac	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3·5	11	28·5	12·5	16	14	31
Ditto mesentery, or mesocolon	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8				
Ditto duodenum	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.	7·5	..	10·5			
Ditto ascending vena cava	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	16			
Sacculated aneurism	93·5	98·4	58·5	51	..	..	27·5	61	50	31·4	62·5	81·3	..	..	..	..	50·	34·8	81	59·7				
Aneurismal dilatation of vessel	6·5	1·7	39	37	..	..	20	20	85·7	85 7	20·8	8 3	..	..	..	..	57·7	28·3	13.3	10·4				
Character of aneurism not defined	..	..	2 5	12	..	..	2·5	22·5	..	..	25	10·4	..	..	..	..	3·8	37	5·6	31·2				
Erosion of sternum, or ribs (anteriorly)	..	..	27	27	..	..	..	16	21	21	..	4·2												
Erosion of vertebræ	..	..	..	1	..	..	..	5	..	1·5	25	41·7	..	..	..	..	..	74	28·3	55				
Pulsating tumour	..	7·4	..	34	..	..	..	44	..	30	..	6·3	..	..	..	..	..	26	..	55				
Murmur	..	34·5	..	23	..	2	..	15	..	22	..	23	..	..	..	..	..	4 3	..	25				
Dyspnœa	..	38·	..	51	.	12	..	71	..	74·3	..	50	..	..	..	..	..	26	..	8				
Orthopnœa	..	10·3	..	18	..	6	..	20	..	21·5	..	19	..	..	..	..	..	4·3						
Cough	..	24	.	36	..	..	..	57·5	..	47	..	46	..	..	..	..	..	24	..	2 5				
Hæmoptysis	..	8·5	..	4	..	..	..	19	..	10	..	27	..	..	..	..	..	19·5						
Stridor, or affection of voice	..	..	..	3	..	..	..	47·5	..	17	..	25												
Dysphagia	..	1·5	..	2	..	..	..	31·	..	21·5	..	33·3	..	..	..	..	..	8 7	..	6·5				
Pain	..	20·7	..	40	..	8	..	36·	..	46	..	62·5	..	..	..	..	..	67·3	..	73				

An abstract of the above, relating to the aorta and its aneurisms, was in print a year ago, when, at the suggestion of a friend, I resolved to extend my inquiry as to those aneurisms, and to give the results here. With this view I have examined the preparations of aneurism of the aorta contained in the museums of Fort Pitt and the College of Surgeons, and of Guy's, King's College, The London, The Middlesex, St. Bartholomew's, St. George's, St. Mary's, St. Thomas's, and University College Hospitals; and I have analysed all such cases as I could find in The Transactions, the Journals, and published works. I have been mainly indebted to the important memoirs of the Dublin physicians, Dr. Corrigan, Dr. Beattie, Dr. Stokes, Dr. Porter, Dr. Smith, Dr. Law, Dr. Bellingham, Dr. Lyons, Dr. Mayne, Dr. Greene, and Dr. Lees, and to those of Scarpa, Mr. Hodgson, Mr. Thurnam, Dr. Hope, Dr. Watson, M. Rokitansky, Dr. Crisp, Dr. Peacock, Dr. Blakiston, Dr. Gairdner, Dr. Todd, and M. Forget. I have rejected those cases that did not give a distinct account of the exact position of the aneurism. The numbers given in the analysis of the anatomical conditions, signs, and symptoms, are necessarily below the actual number, since several of the signs and symptoms were in many cases omitted. As a rule, the signs are more frequently omitted than the symptoms. This applies to all the cases reported before the days of Laennec. On the other hand, some later observers have dwelt on the signs at the expense of the symptoms.

EXPLANATION OF PLATE XV.

This Plate was taken, in St. Luke's Workhouse, through the kindness of Mr. Harris, from the body of a man, aged thirty-eight, of large stature and robust proportions.

In the neck, the soft palate, and a portion of the cricoid cartilage have been removed, exposing—the tonsils, the top of the tongue, and the interior of the larynx.

In the chest—The trachea and lungs, and the thoracic aorta have been removed exposing—the heart and great vessels, and the recurrent nerves.

In the abdomen—most of the viscera have been removed, exposing—the liver, its vessels and ducts, the gall-bladder and the pelvic organs.

Explanation of the Tables.—In the following analysis, the total number of cases of each class appears in the vertical columns of figures. The horizontal figures following each subdivision refer to the cases in my own note-book. By means of these figures, the various particulars given as to each case may be tracked. Thus if we take Case 8, Table II., we find—that the aneurismal sac was seated above the junction of the right and left coronary valves—that it was of the size of a hen's egg—that it ruptured into the pulmonary artery, and compressed that artery and the right ventricle and auricle—that the heart was large, the right and left ventricles being dilated, their walls being thin—that during life a systolic murmur was audible, and that the patient had symptoms of heart disease, dyspnœa, cough, hæmoptysis, and pain in the region of the heart. In the same way the various relations of each group can be separately examined.

I can only give here the two following Tables, but intend to add the remaining Tables in a contemplated work on the Aneurisms of the Aorta.

Table II.—CASES OF ANEURISM OF THE SINUSES OF VALSALVA.

SITUATION OF ANEURISM.

(In this and the following Table the Museum specimens, without history, are in ordinary figures; the cases, with history, in long figures.)

Museum Specimens.	Cases.	
6	10	Aneurismal sac above right coronary valve, 5. 12. 14^1. 17. 27^1. 28^2+5. 6. 16. 20. 29. 34. 37. 38. 42. 58.
6	3	Ditto above junction of rt. and lt. cor. v., 6. 10. 16. 1). 22. 24+8. 17. 54.
4	4	Ditto above left coronary valve, 9^1. 14^2. 18. 20+21. 43^1. 47. 52.
1	2	Ditto above junction of left cor. and intercoronary valves, $13^{1,2}$+45. 53.
4	9	Ditto above intercor. v., 1. 7. 9^2. $27^{2,3}$+15. 18. 23. 33. 35. 36. 41. 43^2. 46.
2	7	Ditto above junct. of intercor. and rt. cor. v., 2. 21+7. 12. 39. 44. 55. 56. 57
2	3	Ditto at anterior aspect of aorta, 25. 29+40. 49. 50.
6	20	Ditto above one valve, which, not stated, 3. 4. 8^2. 11. 23. 28^1+1. 2 3. 4. 9. 10. 11. 14. 19. 22. 24. 25. 26. 27. 28. 30. 31. 32. 48. 51.
2	1	Aneurismal dilatation of aorta above the three valves, 15. 26+13.
33−4=29+59−1=58		

SIZE OF ANEURISM (Mere Ulceration, —10).

Pea, $27^{2,3}$; Nut, 7^2. 9^2. 13^2. 14^2. 20. 22^2. 23. 24. 27^1. 28. 29+2. 5. 6. 9. 25. 30. 48. 55; Small, $4^{1,2}$+43^2; Walnut, 6. 7. 8. 9. 10. 12. 13. 16. 18. 22+4. 23. 26. 32. 35. 36. 42. 54. 58; Plum, 2. 3. 5. 19+19. 37. 38. 46; Apple, 25+39; Pigeon's Egg, 1+7. 44. 50. 52. 57; Hen's Egg, 11+7. 8. 12. 15. 33. 40. 43. 49. 55. 56; Orange, 17. 26. 28+17. 18. 20. 21. 27. 31. 47. 53; Cricket-ball, 15+1. 13. 29. 34; Large Melon, 21; Cont. Quart. 14; Large, 3.

THERE WAS RUPTURE OF ANEURISM INTO THE

Museum Specimens.	Cases.	
10	26	Pericardium, 1. 2. 5. 7. 8. 10. 16. 18. 27. 29+2. 4. 6. 9. 10. 11. 22. 23. 25. 26. 27. 28. 31. 32. 35. 38. 39. 40. 41. 42. 43. 44. 45. 48. 49. 58.
3	8	Pulmonary artery, 6. 11. 12+8. 17. 18. 24. 30. 50. 51. 54.
	5	Right auricle, 12. 13. 33. 34. 56.
	6	Right ventricle, 5. 16. 47 (3); Left ventricle, 36. 37. 52 (3).
1	1	Right lung, 21+3. ?
14	46	
—	1	Perforated by needle shortly before death, 14.
15	11	No rupture.
29	58	

THE ANEURISMAL SAC MADE PRESSURE UPON THE

Museum Specimens.	Cases.	
9	18	Pulmonary artery, 5. 6. 11. 12. 15. 22. 23. 26. 29+1. 4. 8. 17. 18. 20. 24. 30. 34. 40. 47. 49. 50. 51. 52. 54. 55. 56.
5	11	Right ventricle near the pulmonary valves, 22. 23. 24. 25. 29+1. 5. 7. 8. 16. 20. 29. 41. 47. 52. 55.
4	16	Auricular portion of the right auricle, 5. 13. 15. 25+1. 7. 8. 12. 13. 20. 29. 31. 33. 34. 38. 41. 47. 52. 55. 56.
	8	Right and left auricle, 2. 16. 30. 39. 53 (5); Left auricle, 13. 45 (2).
	4	Left ventricle, 5. 36. 37. 47.
	1	Descending vena cava, 34.
1	2	Right lung, 21+3; Left lung, 14.

CONDITION OF HEART.

Museum Specimens.	Cases.	
3	17	Heart large, 5. 6. 15+1. 5. 6. 7. 8. 12. 13. 15. 16. 31. 33. 37. 39. 43. 53. 57. 58.
3	10	Left ventricle hypertrophied, 37. 43; dilated (walls thin), 8. 15.; hyp. and dil. 6. 15+12. 13. 15. 33. 53. 57; large, 5.+39.
	8	Right ventr. hyp. 13; dil. 1. 8. (walls thin) 33. 43. 58; hyp. and dil. 7. 15.
	4	Right ventricle unusually small, 5. 19. 29. 39.
	3	Aortic valves diseased, 52. 55. 57.
1	4	Pericardium adherent, 15+3. 13. 20. 57.

PHYSICAL SIGNS DURING LIFE.

	Cases.	
	2	Pulsating tumour to left of sternum, 14. 20.
	2	Puls. tum. to right of sternum, 3 (bet. 5 and 6 ribs); pulsation to rt. of stm. 12.
	1	Diastolic impulse noticed, 5.
58	20	Murmur noticed, 4. 12. 15. 19. 24. 47. 55; systolic, 8. 30; diastolic, 14. 53; double, 5. 7. 13. 16. 18. 33. 46. 52. 57.
	2	Murmur stated to be absent, 35. 48.
	6	Murmur not noticed, the patient might have been examined, 3. 12. 20, 29 36. 39.
	30	Physical signs were not observed.
35	20	Died suddenly, in general unexpectedly, 2. 4. 6. 9. 10. 11. 22. 23. 25. 28. 34. 35. 40 (epigastric pain same morning) 42. 43. 44. 45. 47. 49. 56.
	4	Died within half an hour of fatal attack, 32. 38. 58(3); Found dead, 41.
	11	Died within 48 hours after fatal attack, 13. 17. 18. 26. 27. 31. 37. 40. 43. 48. 50.
	22	Apparently healthy up to fatal attack, 2. 9. 10. 11. 22. 25. 27. 28. 31. 32. 34? 37. 38. 40. 43 (had amaurosis) 44. 45. (ill 7 days) 48 49. 54. 56. 58.
	6	Had symptoms of heart disease, 8. 15. 16. 19. 39. (angina) 47.
	3	Had phthisis, 46; pneumonia, 30; apoplexy, 19.

SYMPTOMS.

Cases.	
22	Dyspnœa, 1. 3. 5. 7. 8. 12. 13. 14. 16. 18. 20. 21. 24. 29. 33. 36. 38. 42. 47. 50. 52. 57.
5	Orthopnœa, 1. 3. 5. 12. 13.
14	Cough, 1. 3. 5. 7. 8. 12. 13. 17. 18. 29. 33. 35. 47. 50.
5	Hæmoptysis, 3. 8. 17. 29. 33.
1	Dysphagia, 13.
9	Face livid, 1. 12. 13. 36. 47; Great pallor, 4. 17. 18. 24.
9	General anasarca, 3. 7. 12. 13. 16. 47. 51. 52. 53.
12	Pain in region of heart, 3. 5. 8. 20. 24. 26. 31; of chest, 4; 34 in epigastrium, 35. 40. 48.

Table III.—CASES OF ANEURISM OF THE ASCENDING AORTA (ABOVE THE SINUSES OF VALSALVA).

Museum Specimens.	Cases.	
16	37	I. Aneurismal dilatation of the Ascending Aorta to a greater or less extent, 6. 8. 10. 11. 14. 15. 18. 19. 21. 28. 32. 33. 34. 37. 38. 39+1. 2. 3. 6. 7. 8. 9. 12. 16. 18. 19. 25. 28. 30. 35. 37. 43. 44. 47. 51. 52. 55. 58. 61. 63. 71. 74. 75. 82. 84. 85. 86. 87. 89. 90. 91. 95.
6	8	Of these, the dilatation was chiefly in the right wall in 18. 21. 28. 32. 33. 39+1. 2. 12. 47. 58. 63. 82. 86.
1	0	Of these, the dilatation was chiefly in the left wall in 19.
13	35	II A. Aneurismal sac, communicating by an aperture with the Asc. Aorta. the aorta being of normal size, 2. 3. 4. 7. 12. 13. 17. $20^{1,2}$. 23. 24. 26, 27. 31.+4. 5. 10. 11. 23^1. 23^2. 24. 29. 31. 32. 33. 34. 38? 40. 41. 42. 45. 46. 48. 49. 50. 59. 62. 66. 69. 73. 77. 78. 79. 80. 81. 83. 92. 93. 96. 98.
11	16	II B. An. sac, comm. with Asc. Aorta, the Asc. Aorta being itself affected with aneurismal dilatation, 1. 5. 16. 22. 25. 29 30. 35. 36. 40. 41+15. 21. 26. 53. 54. 57. 64. 67. 68. 72. 76. 88 .94. $97^{1,2}$. $99^{1,2}$. 100.
		In II. A. & B. the position of the aperture of communication in the wall of the Aorta was just above the sigmoid valves in 15. 34. 45. 79. 92.=(5) just above the right auricle in 27; about midway between valves and arteria innominata, 2. 4. 5. 7. 12. 13. 20. 22. 23. 25. 26. 35. 36. 41.=(14)+11. 40. 54. 57. 59. 66. 80. 81. 93. 94. 97. 99^2=(12), just below the art. inn. in 17. 24. 30. 31. 40=(5)+21. 23^2. 31. 32. 48. 59^2. 62. 76=(8).
		Aspect of aperture of communication, right, 13. 20. 22. 23. 24. 26. 29. 36=(8). 10. 32. 41. 42. 69. 73. 76. 79. 94. 100=(10); right anterior, 1. 7. 30. 35=(4) 4. 48. 49. 50. 53. 57. 78. 97=(8); right posterior, 31+96; anterior, 5. 12. 17. 27. 40. 41=(6). 15. 31. 32. 34. 38. 46. 72. 80. 92=(9); left, 25+26. 64. 68. 77. 88. 99^1=(6); posterior, 59. 66. 98=(3).
		Diameter of aperture of communication, very small (probe) 16+81; small, 41. 42. 88; about ½ inch, 4. 26+46. 59. 93, 1 inch; 17. 25. 27. 35. 36+64. 66. 73. 74. 96; 1½ inch, 12. 22. 24. 30. 31. 40. 41+10. 29. 32. 33. 69. 83. 94. 100; 2 to 2½ in. 7. 23. 29+24. 46. 49. 76. 97; wide, 16. 20+34. 38. 48. 57. 80.
1	12	III. Aneurism of Ascending Aorta, precise character not specified, 9+13. 14. 17. 20. 22. 27. 36. 39. 56. 60. 65. 70.
41	100	

SIZE OF ANEURISM.

Nut, 1^2. 2. 27.+41. 93; Small, 46; Walnut, 1^1. 9. 25^2+23; Of moderate size, 11; Pigeon's Egg, 3+42. 81; Hen's Egg, 16+21^2. 22. 24. 36. 57.; Diam. about 2 inches, 20^1. 25^1. 29^1. 30^1. 40^1. 41^1+16. 28. 35. 37. 51. 67. 89. 90. 96^1; Diam. 2½ to 3½ inches, 35^1. 36^1+65. 73. 85. 88^1. 96^2; Orange, 4. 11. 12. 24. 31+1. 15. 30. 31. 32. 47. 54 56. 59. 76. 80. 83; Fist, 2. 5. 6. 19. 29. 62. 63; Cricket-ball, 13, 21. 22. 28. 32. 33. 40^2. 41^2.+91. $97^{1,2}$; Small Melon, 23. 29^2. 30^2; or 4 to 6 in. 15. 17^2. 38+14. 26. 66, 69. 79. 88^2. 92. 94. 95; Large, 5. 6. 7. 18. 19. 20^2. 34. 35^2. 36^2. 37+7. 9. 21^1. 33. 34. 38. 43. 44. 48. 55. 58. 68. 71. 72. 74. 86; Very large, 10+10. 17. 18 27. 49. 52. 53. 60. 61. 87.

THERE WAS RUPTURE OF ANEURISM INTO THE

Museum Specimens.	Cases.	
6	22	Pericardium, 1. 3. 9. 16. 26. 27+11. 12. 20. 22. 23. 39. 40. 45. 46. 50. 51. 54. 56. 67. 74. 75. 81. 82^2. 83. 91. 93. 97^2.
2	5	Pulmonary artery, 12. 16 (2)+6. 7. 61. 99^2. (4) Right auricle, 58.
2	5	Vena cava descendens, 13. 31+1. 2. 57. 63. 70.
1	2	Trachea, 4. (1.); mediastinum 89. (1.); pleura, side not stated, 24. (1.).
	9	Right bronchus, 29. 47. 90. (3.); R. lung, 38. 48. 55 69. 79. (5.); R. pleura 13. 69. (2.)
	5	Left lung, 36. 37. (2.); Left pleura, 34. 36. 77. 95. (4.)
1 ?	8	Externally, 17. ?+14. 31. 32. 33. 49. 60. 64. 83.
	1	The sac ruptured, where into, not stated, 34.
12	57	
29 ?	43	no rupture.
41	100	

THE ANEURISM MADE PRESSURE UPON THE

Museum Specimens.	Cases.	
1	2	Heart, 38; right auricle, 19; right auricle and ventricle, 95.
3+1	3	Pulmonary artery, 12. 16. 25+6. 40. 87 = Right pulm. art. 19.
9	7	Vena cava descendens, 13. 18. 19. 28. 30. 31. 32. 36. 38+1. 2. 44. 70. 78. 80. 87.
3	6	Trachea, 18. 19. 38+3. 4. 21. 38. 43 57.
1	6	Right bronchus, 7+24. 25. 76. 87. 100. (5); Left bronchus, 5.
	7	Both lungs, 5. 27. 37. 38. 62. 70. 95.
12	22	Right lung, 5. 7. 21. 22. 23. 28. 29. 30. 33. 35. 36. 41+10. 17. 18. 30. 31. 33. 38. 48. 49. 50. 53. 56. 65. 69. 73. 76. 78. 79. 86. 94. 97. 100.
	10	Left lung, 14. 26. 34. 52. 60. 62. 64. 66. 77. 87. 100.
1	2	Œsophagus, 18+55. 87.

CONDITION OF HEART.

Museum Specimens.	Cases.	
7	33	Heart large, 5. 10. 13. 15. 25. 37. 38+1. 4. 7. 8. 15. 16. 18. 24. 28. 31. 32. 40. 43. 49, 53. 58. 63. 64. 65. 67. 72. 73. 76. 80. 90. 91. 92. 95. 96. 98. 99.
6	14	Left ventricle hypertrophied, or dilated, or both, 5. 10. 13. 25. 37. 38+4. 25. 32. 40. 49. 64. 72. 73. 80. 91. 92. 95. 96. 98.
1	3	Right ventricle, ditto ditto, 13+24. 31. 98.
	5	Pericardium adherent, 1. 10. 95. (3.) Pericarditis present, 30. 33. (2.)
2	22	Heart stated to be healthy, 9. 11+6. 11. ? 12. 15. 22. 23. 26. 45. 47. 51. 52. 55. 59. 66. 68. 69. 70. 77. 79. 86. 87. 94.
32	44	Cases in which the condition of the heart is not specified.

EROSION OF

Museum Specimens.	Cases.	
4	4	Centre of sternum (usually just below manubrium), 17. 18. 30. 41+6. 27. 62. 70.
8	12	Right edge of sternum ditto 7. 22 23. 28. 29. 30. 35. 36.+17. 30. 31. 32. 38. 49. 53. 73 .78. 79. 86. 97.
	4	Left edge of sternum ditto 14. 52. 77. 87.
	1	Right and left costal cartilages or ribs, 62.
9	14	Right cost. cart. or ribs, 7. 22. 23. 28. 29. 30. 35. 36. 41+10. 17. 31. 38. 48. 49. 50. 53. 65. 69. 78. 79. 86. 97.
	6	Left cost. cart. or ribs, 52. 60. 64. 77. 87. (5.) Left clavicle, 14.
	1	Dorsal vertebræ and adjoining left ribs, 66.

PHYSICAL SIGNS DURING LIFE.

	Cases.	
	5	Pulsating tumour at centre of sternum, 5. 27. 37. 62. 95.
	20	Ditto to right of sternum, 10. 17. 18. 30. 31. 32. 33. 38. 48. 49. 50. 53. 65. 69. 73. 76.; (pulsating fulness,) 78. 79. 86. 94
	8	Ditto to left of sternum, 14. 26. 34. 52. 60. 64. 77. 87.
	1	Ditto, side not stated, 72.
100	23	Murmur noticed, 2. 3. 7. 15. 16. 24. 26. 27. 29. 30. 34. 47. 49. 54. 57. 61. 63. 67. 76. 77. 78. 79. 98.
	14	Murmur stated to be absent, 1. 5. 25. 31. 32. 33. 35. 36. 37. 38. 48. 52. 68. 97.
	25	Murmur not noticed, though the patient was, or might have been examined.
	38	Murmur was not listened for, of these 26 were before the days of Laennec.
	15	Died suddenly, 12. 19. 20. 23. 39. 41. 42. 43. 45. 56. 58. 74. 92. 93. 99.
	11	Apparently healthy up to fatal attack, 23. 39. 41. 42. 45 46. 56. 58. 74. 92. 93.

SYMPTOMS.

Cases.	
51	Dyspnœa, 1. 2. 4. 5. 7. 8. 9. 10. 13. 15. 16. 21. 24. 25. 27. 28. 30. 31. 34. 35. 37. 38. 43. 44. 45. 47. 48. 49. 52. 53. 59. 60. 61. 62. 63. 68. 69. 72. 76. 77. 78. 79. 80. 81. 87. 90. 94. 95. 96. 98. 100.
18	Orthopnœa, 7. 10. 15. 16. 21. 24. 25. 34. 48. 61. 68. 69. 77. 78. 79. 90. 95. 98.
36	Cough, 1. 2. 4. 5. 8. 9. 11. 19. 21. 24. 25. 27. 28. 29. 30. 31. 33. 34. 35. 47. 49. 52. 55. 62. 63. 64. 66. 67. 68. 76. 78. 79. 80. 81. 94. 98.
3	Voice raucous, 3; Stridor, 3. 4. 25.
2	Dysphagia, 11. 33. (when recumbent).
29	Pain in chest, 15. 18. 21. 25. 26. 27. 29. 30. 31. 34. 36. 38. 44. 49. 51. 53. 54. 55. 59. 62. 67. 69. 71. 76. 77. 79. 95. 96. 97.
10	Pain in neck and shoulders, 2. 5. 32. 49. 62. 63. 66. 76. 78. 79.
6	Pain in right arm, 33. 48; hypochondrium, 11; back and loins, 6. 61. 66.

Fig 1.

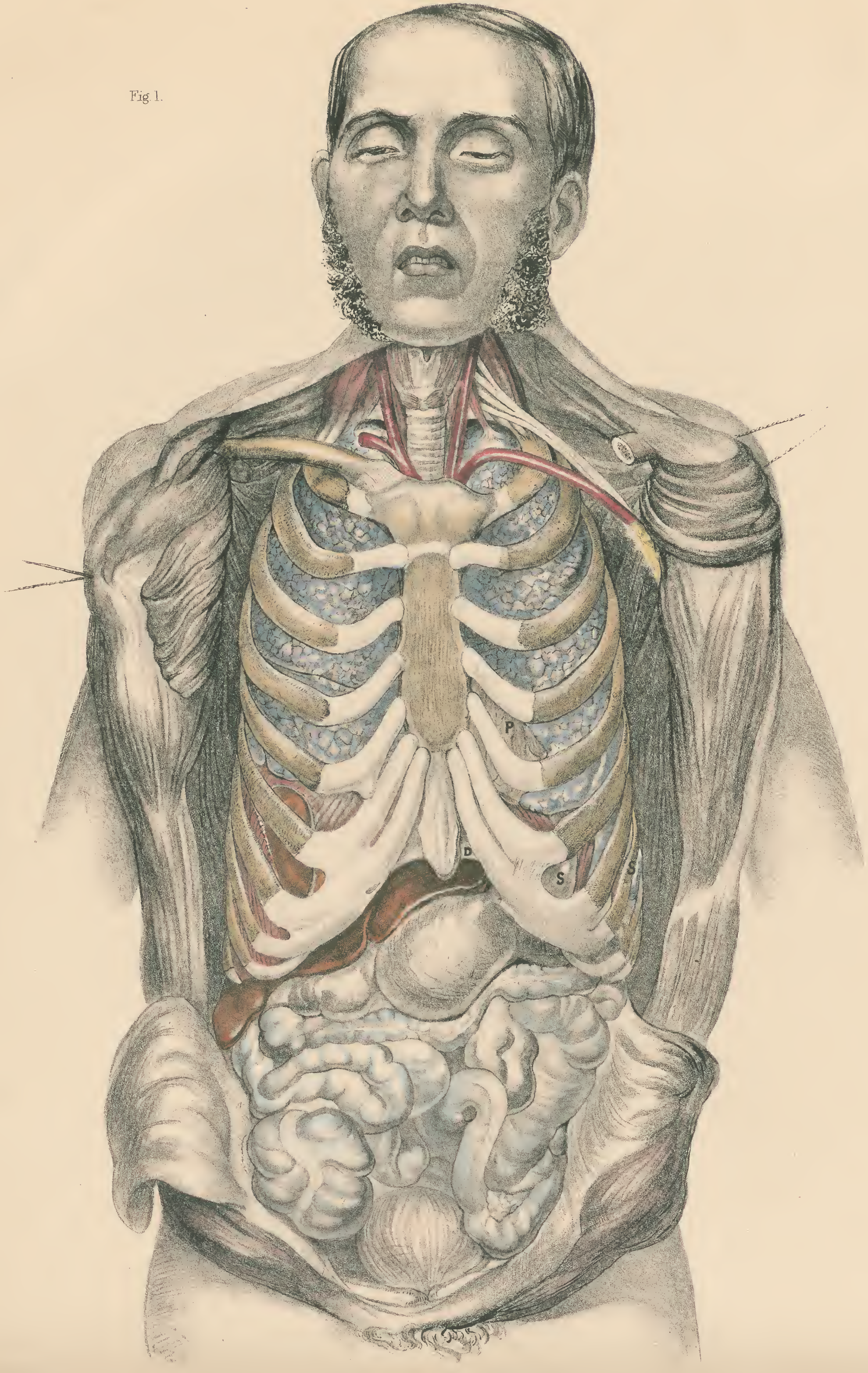
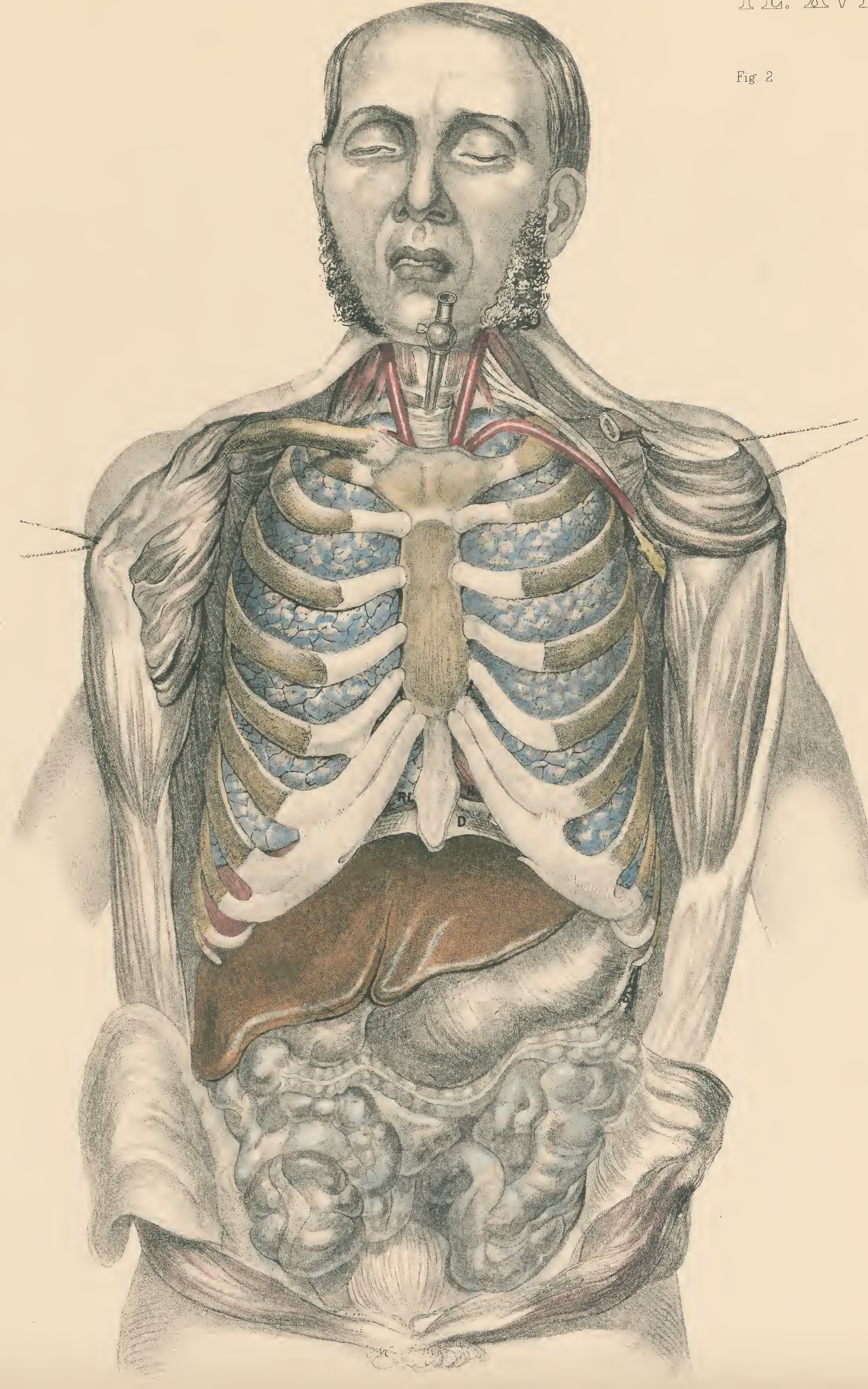


Fig. 2



COMMENTARY ON PLATES XVI., XVII., & XVIII.*

ON THE EFFECTS OF NATURAL AND ARTIFICIAL RESPIRATION ON THE EXTERNAL FORM AND THE INTERNAL ORGANS.

These three plates, which present front, side, and back views, are in pairs. In each, one figure is taken from the body just as it was when laid open, the trachea having been secured to prevent the farther collapse of the lungs; the other figure is from the same body after the complete inflation of the lungs, when they, the other organs, and the ribs have nearly the same position as at the end of a forced inspiration.

The ribs offer greater resistance than the diaphragm to the artificial inflation of the lungs; consequently, while the expansion of the ribs is less, the descent of the diaphragm and abdominal organs and the expansion of the abdomen are greater than at the end of a forced inspiration. The difference in these respects, however, in the effects of artificial and natural respiration, is not great. This is rendered evident by the series of photographs now before me, from an Academy model, taken during forced expiration and inspiration.

Allowance being made for those deviations, these views represent the influence of forced expiration and inspiration on the size and shape of the chest and abdomen, the volume of the lungs, and the raising and lowering of the heart, the diaphragm, and the abdominal organs. They put the machinery of the body in motion, and furnish us with a knowledge of the living movements which take place in the interior as well as on the exterior of the body during the act of breathing.

THE RIBS AND DIAPHRAGM.

Snakes, lizards, and birds breathe by means of ribs alone, the diaphragm being either absent or subsidiary. In man, as in the other mammalia, the ribs share the act of breathing with the diaphragm, the ribs being so moulded as to adjust themselves to the diaphragm. The cage of the chest is cone-shaped, and vaulted towards the apex. During inspiration, when the floor of the chest, formed by the diaphragm, is lowered, the costal walls enlarge, and the vaulted roof expands and rises so as to cause general expansion of the lungs.

The middle series of ribs, from the fourth to the eighth, present a general conformity. They are joined to the sternum by cartilages, and bend backwards from the vertebræ so as to form a hollow for the lungs posteriorly. During inspiration, the ribs bearing on the vertebræ, and the cartilages bearing on the sternum, are raised sideways, so as to widen the chest; while the anterior extremities of the ribs, carrying the cartilages, are raised, and move forwards, and the posterior portions move backwards, so as to deepen the chest.

The seventh cartilages of opposite sides, from their articulation with the end of the sternum, form the limbs of a pair of compasses, which diverge, and widen the epigastrium† during inspiration, and which converge, and narrow the epigastrium during expiration.

* For extended details of the subject of this Commentary, I refer to my papers "On the Mechanism of Respiration," in the Philosophical Transactions for 1846; "On the Movements of Respiration in Health and Disease," in the Med. Chir. Trans. for 1848; "On the Situation of the Internal Organs," in the Prov. Med. Trans. for 1844; and "On the Causes which Excite Respiration," in the Prov. Med. Trans. for 1850.

When viewed sideways, the fourth, fifth, and sixth ribs curve upwards, the seventh rib is straight, while the eighth and ninth ribs curve downwards. During inspiration, these ribs, while they diverge from each other, become more nearly parallel.

While there is this conformity between the middle series of ribs, from the fourth to the eighth, there is a complete contrast between the three upper and the three lower ribs.

The first ribs form a pair of short strong girders, which only move at their articulation with the vertebræ. The three upper ribs increase rapidly in size, the second being twice as long as the first. The summit of the chest is closed in and vaulted over by this series of enlarging ribs. There is, on the other hand, a wide open space, occupied by the abdominal viscera, between the free anterior extremities of the three lower ribs of opposite sides.

During inspiration, the three upper ribs converge, the movable second rib being drawn much nearer to the immovable first rib by the combined action of both intercostal muscles: those ribs also move entirely forwards, so as to expand the upper lobe. The three lower ribs, on the other hand, diverge like a fan; and they move entirely backwards, so as to expand the lower lobe. During expiration, they are approximated by the combined action of both intercostals.

The four lower ribs give origin to the diaphragm. They enlarge both its circumference and that of the lower lobe during inspiration, when the diaphragm lengthens those lobes downwards, and displaces the liver, stomach, and spleen from within the shelter of the lower ribs. Since these ribs participate thus in action with the diaphragm, I have named them the *diaphragmatic* ribs; discarding the incorrect term "*false*," because they work as truly as the so-called *true* ribs; as well as the term "*floating*," since, though they appear to float in the dead body, they are steadied in the living body by powerful respiratory muscles.

The five upper ribs act exclusively on the upper lobe, and have no bearing on the lower lobe, or the diaphragm. Their relations are entirely thoracic, and I have therefore named them the *thoracic* ribs.

The sixth, seventh, and eighth ribs move in common, because their cartilages are conjoint, and form an intermediate set, which are mainly thoracic during inspiration, but which, during expiration, like the diaphragmatic ribs, co-operate with the diaphragm.

The ribs increase in length from the first to the seventh and eighth; consequently, during inspiration, when the chest is deepened by the elevation of the ribs, the lower portion of the sternum is pushed forwards more than the upper, and the dorsal vertebræ are pushed backwards to an increasing extent from the fourth to the eighth or ninth rib, so as to increase the curve of the dorsal spine. Since the arc of the spine is deepened, the chord of the arc is shortened, and, therefore, during inspiration, the length of the dorsal and cervical portions of the spinal column is shortened. If the inspiration is volun-

† By *epigastrium* is meant the triangular space below the lower end of the sternum, and between the right and left seventh and eighth cartilages.

EXPLANATION OF PLATE XVI.—FRONT VIEWS.

In this and the two following Plates, the body is exhibited under two aspects. In Fig. 1, the lungs are collapsed as in expiration; in Fig. 2, they are inflated to the full, as in forced inspiration. In order that the lungs in Fig. 1 might retain the exact quantity of air that they held after the last expiration, I inserted into the trachea a tube, the stop-tap of which was turned before opening the chest.

The intercostal muscles are removed, and the bony cage of the chest is left so as to expose the organs within it through the intercostal spaces.

It was difficult, and took a great deal of time to make the drawings in these plates. The difficulty lay not in the figures of the collapsed lung representing expiration, but in those of the inflated lung representing inspiration. In the former, the lungs, the other organs and the ribs were permanently at rest; in the latter the air escaped very gradually from the lungs, thus necessitating a renewal of the inflation from time to time. Owing to the length of time occupied in making the dissections and drawings, this could not be avoided. To lessen this source of error as much as possible, I took separate outlines of the body, both when the lungs were distended and collapsed, in addition to those made for the actual drawings. When making the reduced drawings, constant reference was made, rib by rib, to those outlines, and to the costal walls, which were preserved, of each of the three bodies figured in these Plates. Every effort was made to attain accuracy, and I believe that these drawings are substantially correct.

In Plate XVI., fig. 1, representing expiration, the collapsed lungs and pericardium (P), the diaphragm, in part cut away, and the liver, stomach (St), and spleen (Sp), where exposed by the removal of the diaphragm, are seen through the intercostal spaces. In Fig. 2, representing inspiration, the distended lungs almost exclusively occupy the intercostal spaces, the right lung (L) appearing below to the right of the xiphoid cartilage. The heart (H) is covered by lung within the ribs and intercostal spaces, and is lowered and exposed to the left of the xiphoid cartilage, resting, like the tip of the left lung, there seen also, and the right lung, on the diaphragm (D).

(The figures in Plates XVI., XVII., XVIII. are reduced from 32 inches to 12·1 inches.)

tary, the shortening of the cervico-dorsal spine is often more than counterpoised by the backward movement of the lumbar spine.

The chest, when looked at with a sole regard to its bony framework, and not to its internal organs, appears much shorter, and the abdomen much longer in front than at the side or back.

In front, the sternum forms the centre-piece and apparent limit of the chest, the neck being bounded by its upper end, the abdomen by its lower end. In appearance the chest, therefore, is short, while the neck and abdomen are long. During a forced inspiration the sternum is much raised, so that the neck is shortened, while the abdomen is apparently lengthened at the expense of the chest.

At the side, the long single range of ribs, and behind, the long double range of ribs and the dorsal vertebræ, convey the impression of a lengthy chest and a very short abdomen.

It is true that the chest is longer behind than in front; but the main difference lies in the deceptive appearance presented by the long array of ribs and vertebræ behind, compared with the short breastbone in front.

Behind and within the ribs are seated not only the lungs, but also those important abdominal organs, the liver, the spleen, the stomach, and a portion of the intestines.

The diaphragm forms the true limit between the chest and abdomen. It is the movable floor of the chest, the movable roof of the abdomen. Its descent lengthens the chest and shortens the abdomen; its ascent lengthens the abdomen and shortens the chest. The diaphragm forms, therefore, the regulator of the size and position of the organs within the chest, and of the position of the organs within the abdomen.

In the majority of males, the thoracic movement during tranquil inspiration is about one-twentieth, the abdominal movement one-third, of an inch. This indicates that the diaphragm descends about half an inch. In the robust, the thoracic movement is even less. In two remarkably well built men, Sewell, the American runner, and the third best English runner, it was only the thirtieth of an inch. In many weak persons, on the other hand, it is as much as the tenth of an inch.

In females, thoracic breathing is greater than in males, diaphragmatic breathing less. While all physiologists are agreed as to the fact, they differ as to its cause. Some consider it to be due to the natural difference in the character of breathing in the two sexes; others, to the habit of wearing stays. The latter opinion is supported by the fact, that when the stays are on the thoracic and diaphragmatic movements are nearly equal, while, when they are off, the thoracic fall from the tenth to the fifteenth or twentieth of an inch, whilst the abdominal rise from the tenth to the fifth of an inch. The respiratory movements of male and female children are alike up to the age of 14.

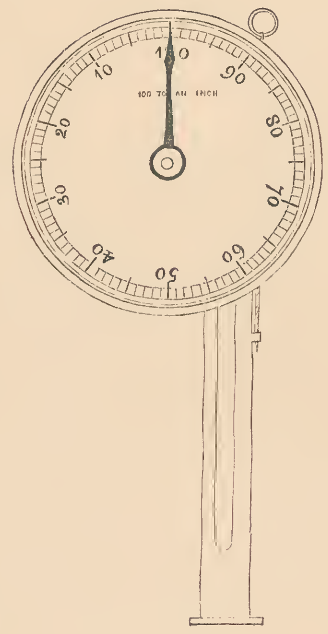
During a forced inspiration, when the combined powers that expand the lungs are all brought into play, thoracic and diaphragmatic respiration are nearly balanced; the walls of the chest and the walls of the abdomen advance almost equally, and from one to two inches; the circumference of the chest and the circumference of the abdomen are nearly alike increased, from two to three, or even four inches. We must bear in mind, however, that a forced inspiration is very different from an ordinary inspiration. The latter is physiological and unconscious, and the proportional movements of the chest and diaphragm are not modified by the emotion or the will; the former is voluntary and conscious: and as the attention is directed to the apparatus of breathing, in some the chest movements are in excess, in others the abdominal; many persons, indeed, breathe entirely by the diaphragm when the abdomen is being examined, entirely by the ribs when the chest is being examined. Usually, however, the abdominal and thoracic movements are about equal, but the epigastrium generally advances much more than the lower end of the sternum.

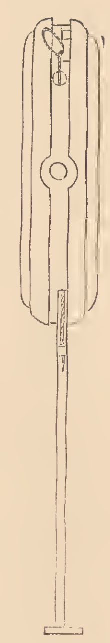
In order to measure the movements of breathing with accuracy, I contrived a Chest-Measurer. It is figured in the adjoining wood-cuts, and described in the Medico-Chirurgical Transactions for 1848. As a rule, it is better to dispense with apparatus, and to apply the hands immediately over the chest when observing its movements: but in many cases they can only be accurately ascertained by mechanical aid.

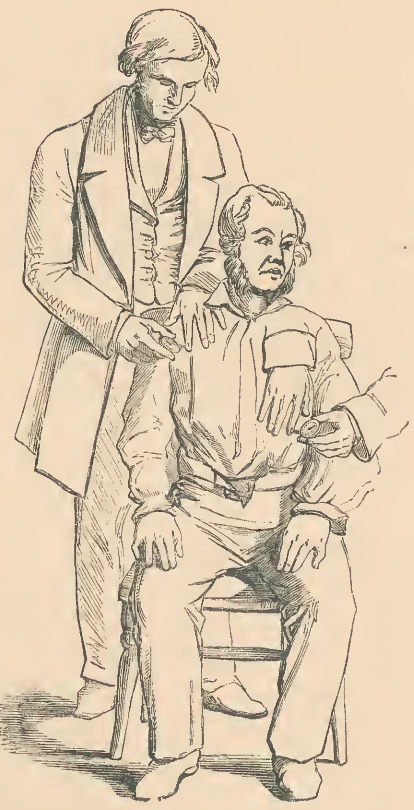
Since my Chest-Measurer* was described, Dr. Quain and Professor Wintrich have invented ingenious instruments for the same purpose. Also Dr. Edwards has recently contrived a pair of callipers for measuring the varying diameter of the chest, to which Mr. Becker has adapted the ~~dial portion~~ of my Chest-Measurer. Each of these instru-
thread movement

* When using the Chest-Measurer, press upon the skin or clothes over the part to be examined with the left fore-finger. Hold the instrument between the thumb and fore-finger of the right hand. Do not rest that hand on the chest itself or the part examined, but steady it on some adjoining fixed object, as the patient's arm. Rest the top of the moving rod on the nail of the left fore-finger, and observe the movements on the dial. Be careful not to humour the movements so as to make them answer to what you expect, by varying the pressure with the left fore-finger, or moving the right hand.

ments has its special advantages. I still prefer my own. It is light, simple, and accurate. It shows, to the hundredth of an inch, the exact movement of the part examined. Its employment, like that of the stethoscope, and every other aid to diagnosis, requires practice. I have not seen the callipers invented many years ago by Dr. Stokes.







Dr. Hutchinson has shown that when a man six feet high takes a deep breath, he inhales nearly a gallon of air. During an ordinary inspiration, he inhales only from half to three-quarters of a pint. Hence, in tranquil breathing, the size of the chest is but little increased; while, in forced breathing, both the chest and the abdomen undergo a marked and unusual expansion.

When we run, we inhale sixteen times as much as when we are tranquil. Tranquil breathing is, therefore, made without effort or display. The descent of the diaphragm, for half an inch, is performed unconsciously. The very slight expansion of the thoracic ribs is made less with the object of directly expanding the lungs than of sustaining the weight of the atmosphere, which would otherwise compress the lungs when they are being lengthened downwards by the diaphragm. If from any cause—such as submersion, suffocation, laryngismus, hiccup, croup, or a foreign body in the larynx—the entrance of air into the lungs is prevented or impeded, the diaphragm continues to act rhythmically, so as to lengthen the yielding lungs downwards. As the atmospheric pressure can no longer act to force the air through the air-tubes into the air-cells, it forces backwards the front of the chest. In one man, suffering from chronic laryngitis, the obstacle was so great that scarcely any air entered the lungs. His face was anxious, ghastly, and covered with sweat. He gasped at each effort at inspiration, when the abdomen protruded, but the chest collapsed half an inch. Tracheotomy was performed. Instantly the chest expanded, breathing was freely re-established, the face became ruddy, the eyes beamed with pleasure, and relief was complete. It was interesting to notice that the nostrils continued to expand, although the air entered the trachea through a tube. The man recovered. Since this was written I admitted a man, affected with contraction of the glottis, into St. Mary's Hospital, who inspired with extreme effort and difficulty. His respiration was hissing, and heard at a

PL. XVII.

Fig. 1.

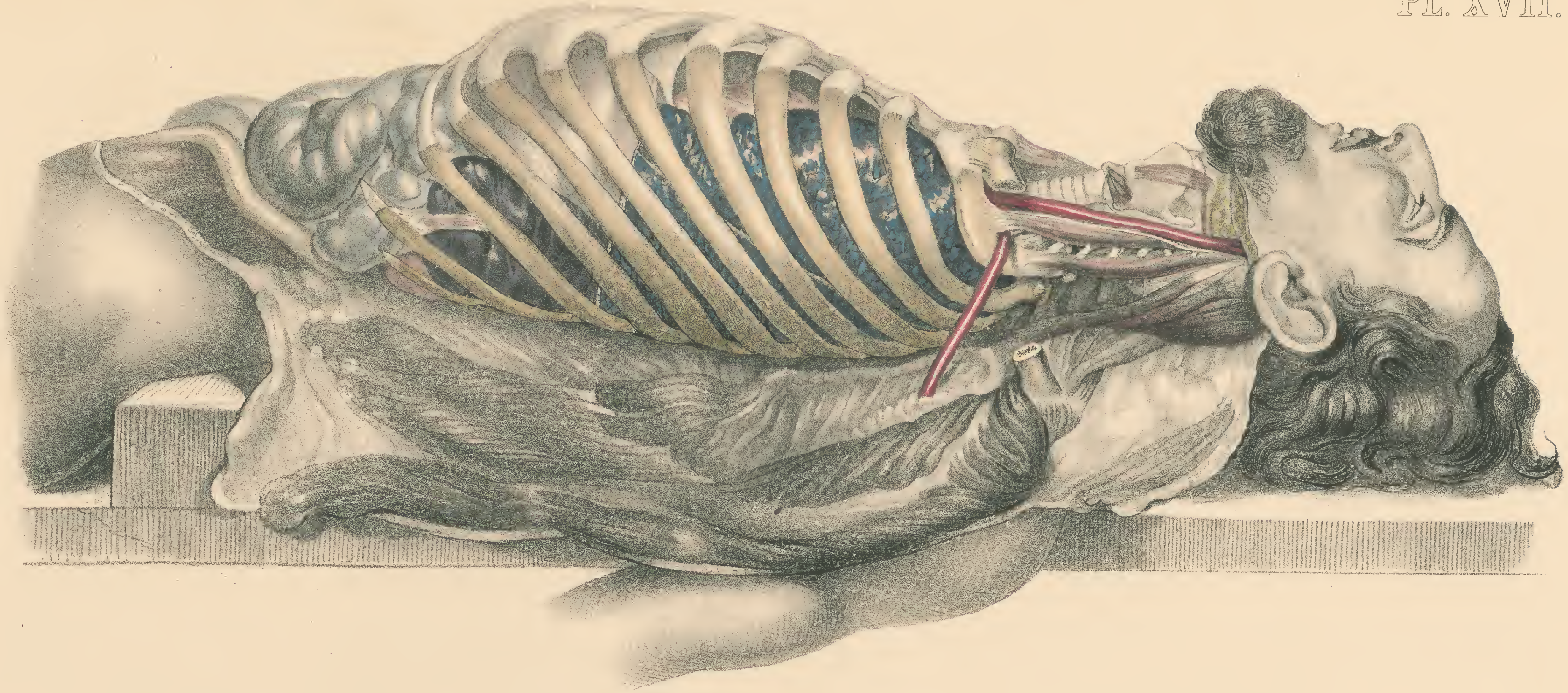
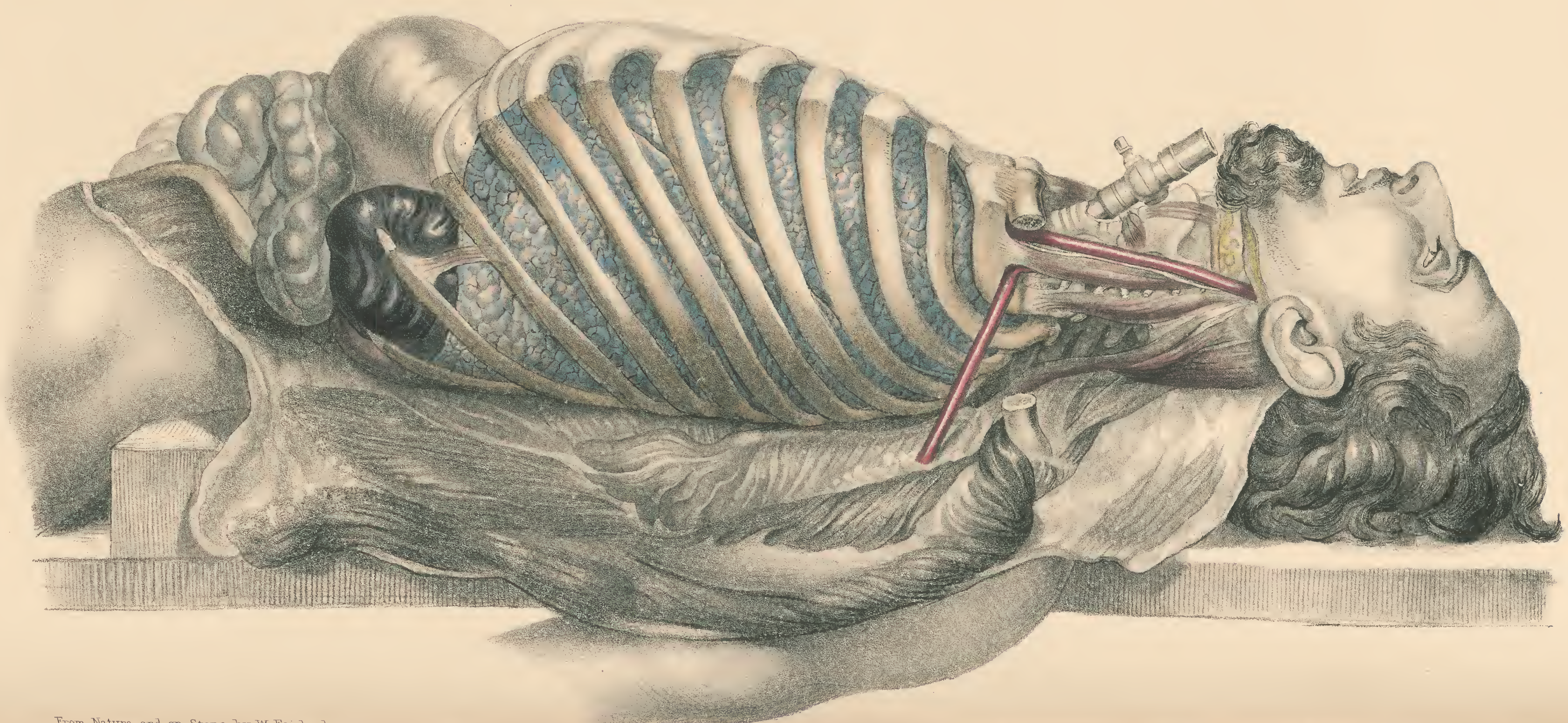


Fig. 2.



From Nature and on Stone by W. Fairland

Printed by Hullmandel & Walton.

distance. Vesicular breathing was barely audible over the chest; he spoke in a whisper. The lower end of the sternum and the epigastrium retracted during each inspiratory struggle, while the upper chest and lower abdomen expanded. The thyroid body was hard and large—it pressed on the trachea; but it evidently to me compressed the left recurrent nerve, whence the narrowing of the glottis. He took six grains of iodide of potassium every three hours for four weeks, when the thyroid body was greatly lessened, breathing was free, the voice had returned, the symmetry of the breathing movements was restored, the breath sounds became natural, and he left the Hospital feeling well.

The diaphragm has an extensive action on many other organs besides the lungs. At each inspiration it draws downwards and lengthens the heart, increasing the size of its cavities, and the blood contained in its right side; it compresses downwards the bulk of the liver, so as gently but firmly to press the blood onwards from the hepatic vena cava into the right auricle—the spleen, with an analogous effect—the pancreas and the kidneys, so as to help onwards their secretions—the stomach and intestines, great and small, so as to churn their contents, and on a deep inspiration the uterus even, the rectum and the bladder.

The expiratory ascent of the diaphragm from the contraction of the abdominal muscles causes the reversal of all these actions, so that every organ is brought alternately under the downward and upward sway of the diaphragm and the abdominal muscles.

It is to be remarked that a deep breath is habitually drawn immediately before every act of expulsion; before the acts of sneezing, speaking, coughing, and natural or hysterical laughing and crying, which are acts of expulsion from the lungs themselves; before those of eructation and vomiting when the stomach is compressed downwards by the diaphragm; before the expulsion of the urine and the fæces; and, finally, before each labour pain. All these expulsive acts are truly efforts of expiration, but in all of them the previous deep inspiration gives additional purchase to the expulsive effort.

The diaphragm must be regarded as a muscle having three distinct portions, the right, the left, and the central, each portion having a different anatomical relation, each its own tendon, each operating on a distinct set of organs, and, although they act combinedly as one muscle, each able to act alone under certain contingencies.

The right portion expands the right lung and lowers the liver and right kidney; the left portion expands the left lung and lowers the stomach, spleen, and left kidney; and the central portion lowers and expands the heart and depresses the left lobe of the liver, the cardiac and pyloric extremities of the stomach, the pancreas, and intestines.

The right portion, which fits like a cap over the upper convexity of the liver, and which in turn is capped by the concave base of the right lung, usually in the dead body rises upwards into the chest as high as the level of the lower edge of the fourth rib in front, the fifth, sixth, and seventh ribs at the side, and the eighth rib behind. This represents its position at the end of an expiration. The concave base of the right lung laps over the right dome of the diaphragm all round, so as to present everywhere a wedge of lung that thins off to a sharp edge between the diaphragm and the ribs, immediately below which, the right diaphragm in its whole circuit presses against the costal pleura.

The right portion of the diaphragm, from its origin at the lower ribs and cartilages, ascends within the ribs, until it is separated from them by the interposed margin of right lung. The costal and diaphragmatic pleuræ glide upon each other from the reflection of the pleuræ to the lower margin of the lungs.

The left portion of the diaphragm is narrower anteriorly than the right, owing to the encroachment of the pericardium. To make up for this, the whole left portion takes a lower pitch than the right. It is lower at the central tendon or summit by about three-quarters of an inch, at its origin from the lower cartilages and ribs by about a quarter of an inch, and intermediately, where the lower edge of the left lung separates it from the costal pleura, by about half an inch. During a deep inspiration the difference between the two sides is maintained.

While the right dome of the diaphragm supports the right lung, and the left dome the left lung, the central portion supports the heart. As during inspiration the descent of the right and left portions of the diaphragm lengthens downwards and expands the right and left lungs, so the descent of its central portion lowers and lengthens the heart.

At the end of the sternum, and at the bodies of the lower dorsal vertebræ, the central portion of the diaphragm is higher than the lateral portions. But deeper, this is reversed, since the central tendon is much higher on the right side, and somewhat higher on the left side, than at the centre, as is shown in Plates IV., XV., IX., XI.

The same Plates show, also, that while each lateral portion of the diaphragm forms a complete arch from the front to the back of the chest, lower behind than in front, the central portion forms a slightly inclined plane from the body of the ninth or tenth vertebræ to the lower end of the sternum, higher behind than in front.

The fibres of the central portion of the diaphragm are inserted into the central tendon, along the base of the pericardium, by one converging muscular web, which stretches from the seventh cartilage on one side to the seventh cartilage on the other side, and arises from each of those cartilages, from the tip of the xiphoid cartilage, and by a distinct slip on each side of that cartilage, from the aponeurosis between the transversalis muscle and the peritoneum.

In some bodies, the muscular slips from the xiphoid cartilage are replaced by a thick triangular aponeurosis. In one such instance, both slips from the abdominal aponeurosis were present; and in two others, one slip was present, the other absent. In these instances, the inner fibres, from each seventh cartilage, instead of passing obliquely backwards to the base of the pericardium, took a course directly inwards to the aponeurosis passing from the xiphoid cartilage to the lower edge of the pericardium.

The diaphragm arises, not from the whole length of the seventh cartilage, but from its lower half only, by fibres which stop short three inches from the articulation of the cartilage with the sternum, so as to leave a triangular gap between it and the xiphoid cartilage, which is filled up during a deep inspiration by the lower edge of the right lung on the right, the heart and the tip of the left lung on the left side.

When we stretch the two inner thirds of the fibres from each seventh cartilage, which ascend inwards to the lower edge of the pericardium, we pull down the pericardium, but produce no effect on either lateral portion of the diaphragm. When we stretch the outer third of the fibres from each seventh cartilage, we lower the lateral convexity of the diaphragm, into the central tendon of which they are inserted, but produce no effect on the pericardium.

When the central fibres of the diaphragm, described above, contract, they draw downwards the cardiac portion of the central tendon, and they lower, lengthen, and stretch the pericardial sac and its aponeurosis, the heart, and the great vessels quite up into the neck.

In estimating the effect of inspiration on the relation of the internal organs to each other, and to the walls of the chest, two elements must be considered: the descent, namely, of the diaphragm, and the ascent of the sternum ribs and cartilages.

During a forced thoracic inspiration, the walls of the chest ascend one inch. If at the same time the diaphragm is stationary, the lower boundaries of the lungs and heart, and the upper boundaries of the liver and stomach, must be stationary also. The cage of the chest must then glide upwards over those organs for the space of an inch, and their boundaries, though really stationary, will be nearly an inch lower in relation to the costal walls.

If while the ribs ascend one inch, the diaphragm, as is usual, descends from one to two inches, then the actual descent caused by the diaphragm must be added to the relative descent caused by the uplifting of the cage of the chest. The lowering of the lungs in relation to the ribs will then be about two inches; that of the heart, an inch and a half; and that of the liver, two and a half or three inches.

LUNGS AND HEART.

The descent of the diaphragm, acting as a piston, lowers and lengthens, by a common operation, both the lungs and heart, which rest on it as on a floor. During a deep inspiration, the inferior margins of the lungs are lowered from the sixth cartilage in front, from the seventh, eighth, and ninth ribs at the side, and from the tenth rib

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EXPLANATION OF PLATE XVII.—SIDE VIEWS.

In Fig. I., representing expiration, the collapsed left lung, the heart, and pericardium occupy the upper portion of the space within the ribs; its lower portion being occupied by the whole of the stomach (S) and spleen, which is large, a part of the kidney and a part of the colon, which are seen through the intercostal spaces. The intestines lie below the ribs.

In Fig. II., representing forced inspiration, the distended lung covers the heart, and occupies the whole space within the ribs down to their cartilages, almost to the exclusion of the stomach. The spleen, though much lowered, is still seated within the base of the left lung and the lower ribs: in this subject it projects just below their tips. The kidney (K) is also lowered, and the intestines are compressed downwards.

behind, to the seventh cartilage in front, to the eighth, ninth, and tenth ribs at the side, and to the twelfth rib behind. The base of the left lung is about half an inch lower than that of the right in its whole circumference at the beginning as at the end of inspiration. The breath-sounds, vocal vibration, and pulmonic resonance on percussion, descend with the descent of the base of each lung.

Since during inspiration the whole of each lung is elongated, the upper lobe as well as the lower, the septum between those lobes is also lengthened and lowered. The septum, above and behind, where it is as high as the spine of the scapula, is only slightly lowered; but below and towards the front, where it bisects the base, severing the upper or middle lobe from the lower, the descent of the septum is as great as that of the base itself. During expiration, the septum usually crosses obliquely the line of the fifth rib, its upper portion being above and before that rib; its lower, below and behind it. During inspiration, it follows the same line of direction in relation to the sixth rib.

The lower boundary of the heart, which rests upon the central portion of the diaphragm, is drawn downwards during forced inspiration by the descent of the central tendon, from the extremity of the sternum almost to the tip of the xiphoid cartilage. While the heart thus descends, the lungs expand downwards and forwards so as to cover a large portion of the heart that was uncovered during expiration. The region of cardiac dulness on percussion, therefore, descends to the epigastrium from the costal cartilages to the left of the lower sternum, where it is replaced by lung resonance. The impulse is also lowered and narrowed. The apex-beat is lost, being masked by lung; and the beat of the right ventricle descends to the left of the xiphoid cartilage. In fact, at the end of a deep inspiration, the lungs absorb the costal walls to the exclusion of every other organ.

During inspiration, owing to the general elongation of the lungs, the great bronchi are drawn downwards. This descent of the bronchi involves that of the trachea and larynx, which is visible in the neck.

The descent of the heart during inspiration causes the like descent of the great pulmonary vessels behind, and the great systemic vessels above the heart.

The pulmonary vessels have the same respiratory play as the bronchi, with which they intertwine as they enter and leave the lungs at their roots. The inspiratory descent of the great vessels at the base of the heart draws down and stretches the great vessels in the neck, which have the same respiratory play as the larynx and trachea.

Thus, during respiration, the alternate action of the diaphragm and the abdominal muscles produces a common downward and upward movement of the heart and lungs, a common lowering and raising of the pulmonary vessels and bronchi, and a common descent and ascent of the vessels of the neck and the trachea and larynx.

The inspiratory deepening of the great vessels and trachea at the root of the neck is greatly increased by the simultaneous rise of the upper edge of the sternum and the clavicles. Thus it is, therefore, in the neck, the chest, and the abdomen, that while the parts and organs situated therein are lowered during inspiration, the whole bony cage of the chest is raised, so that the relative descent of those parts and organs, in their association with the ribs and sternum, is everywhere considerably greater than their actual descent.

ABDOMINAL ORGANS.

When the abdominal organs are pressed upon during a deep inspiration by the descending diaphragm, they are displaced in three directions: downwards, forwards, and sideways. This displacement is not limited to the liver, stomach, and spleen, and the other organs immediately acted upon by the diaphragm, but through their intermedium it spreads downwards also to the lower abdomen, the pelvic viscera, and the perinæum.

During expiration the six lower ribs and cartilages protect the liver on the right side, the stomach and spleen on the left, which organs rest solidly on the posterior muscular sheet of the diaphragm in front of the lower ribs and the wedge of lung at the base. Those viscera, therefore, there occupy the hindermost part of the body. During inspiration, the wedge of lung at the base steadily descends, and is interposed between the lower ribs and the posterior part of the diaphragm, which advances as it descends, and lifts forwards the bulk of the liver, stomach, and spleen. The most striking effect of the inflation of the lungs *in situ* is not so much the descent of those organs, great as that descent is, as the advance of those organs. They appear to be, and they are propelled forwards by an irresistible force, acting *a tergo*, a force allied to that of the Bramah press, pneumatic being substituted for hydraulic pressure.

In estimating the descent and advance of the liver, spleen, and pancreas, the ascent and advance of the lower sternum ribs and cartilages must be taken into account. While the latter ascend and advance about one inch, the former descend and advance nearly two inches. But in relation to the ribs and cartilages, the liver moves downwards about three inches, forwards scarcely one inch, since their elevation adds to its depression, and their expansion lessens its protrusion.

The inspiratory lowering of the liver is notably greater than that of the stomach and spleen, owing to the great height to which it occupies the right dome of the diaphragm. In accounting for the relative inspiratory depression of the liver, we must, therefore, keep in view three causes: the general descent of the diaphragm, the special descent of the right dome of the diaphragm, and the ascent of the right cartilages and ribs.

Under this triple agency, the lowering of the liver would be still greater, but that it is compressible, and that the blood is forced freely out of the hepatic vena cava into the right auricle, which is happily enlarged during inspiration.

The thin edge of the liver usually appears during expiration, just below the xiphoid cartilage, and above the stomach and colon, which combine to form a yielding hollow in the epigastrium, resonant on percussion. This hollow is replaced during a deep inspiration by the liver, which descends towards the umbilicus, stretches across the epigastrium, between the left and right seventh and eighth costal cartilages, and forms an elastic rounded prominence, dull on percussion.

As a general result, the liver during a deep inspiration is compressed and shortened from above downwards, widened from side to side, lowered so that fully one-half of the organ is exposed below the ribs and cartilages, instead of being sheltered almost entirely within them, and thrown forwards so as to be more prominent by from half an inch to an inch than the seventh and eighth cartilages and the xiphoid cartilage, instead of lying quite behind them.

The left lobe of the liver, the stomach, and the spleen, form, in combination, a counterpoise to the right lobe of the liver. While it, during expiration, is protected within the six right lower cartilages and ribs, they lie within the left lower ribs and cartilages. They, like it, also are displaced downwards and forwards during a forced inspiration by the descent of the diaphragm and the base of the corresponding lung, so as to appear to a great extent below the ribs and cartilages.

The shelving edge of the left lobe of the liver overlaps, and, therefore, hides the lesser curvature of the stomach and its pyloric and cardiac orifices, and it does so during both inspiration and expiration, whether the stomach be full or empty. The pyloric extremity of the stomach lies, therefore, below the left edge of the liver, and usually appears during expiration just beneath the xiphoid cartilage, whence it is lowered by a forced inspiration to the level of the umbilicus. The cardiac orifice is drawn downwards by the crura of the diaphragm for about an inch, while the pyloric orifice is pushed downwards and forwards about two inches.

The greater curvature and cardiac extremity of the stomach, unless it is much distended, and the spleen, lie during expiration completely within the lower cartilages and ribs. During inspiration the stomach and the spleen descend together; but while the former is forced forwards to as great an extent as it is downwards, the downward movement of the spleen is much greater than its forward movement.

The spleen, during expiration, lies upon the three or four lower ribs, and the posterior part of the convex base of the left lung. During forced inspiration, the upper part of the spleen is pressed forwards as well as downwards; the lower part, more directly downwards. The inferior edge of the spleen usually descends to the tip of the last rib, or even lower when the organ is large, as in Plate XVII.

During a forced inspiration, while in front the lung makes its way downwards below the lower edge of the sternum; behind, it does not reach by a couple of inches so low as the tip of the last rib. Hence, the lower edge of the spleen on the left side, of the liver on the right side, do not usually descend so low as the extremity of the twelfth rib.

The kidneys are lowered during a forced inspiration from half an inch to an inch, or thereabouts.

The intestines, great and small, are pressed during a forced inspiration downwards, forwards, and sideways; their displacement being effected not by the immediate pressure of the diaphragm, but by the intermediate pressure of the liver, stomach, and spleen. The ascending portion of the colon, just below the liver, and its descending portion just below the stomach and spleen, are the exceptions to this rule, they being immediately acted on by the diaphragm. When the stomach is full, as in Plate XVII., it fills up the space within the ribs below the left portion of the diaphragm. When, however, the stomach is empty, the space previously occupied by it is filled up, as in Plate XVIII., by the descending portion of the colon.

The pelvic organs are subjected, during a forced inspiration, to the downward pressure communicated to them from the diaphragm by the

PL. XVIII

Fig. 1

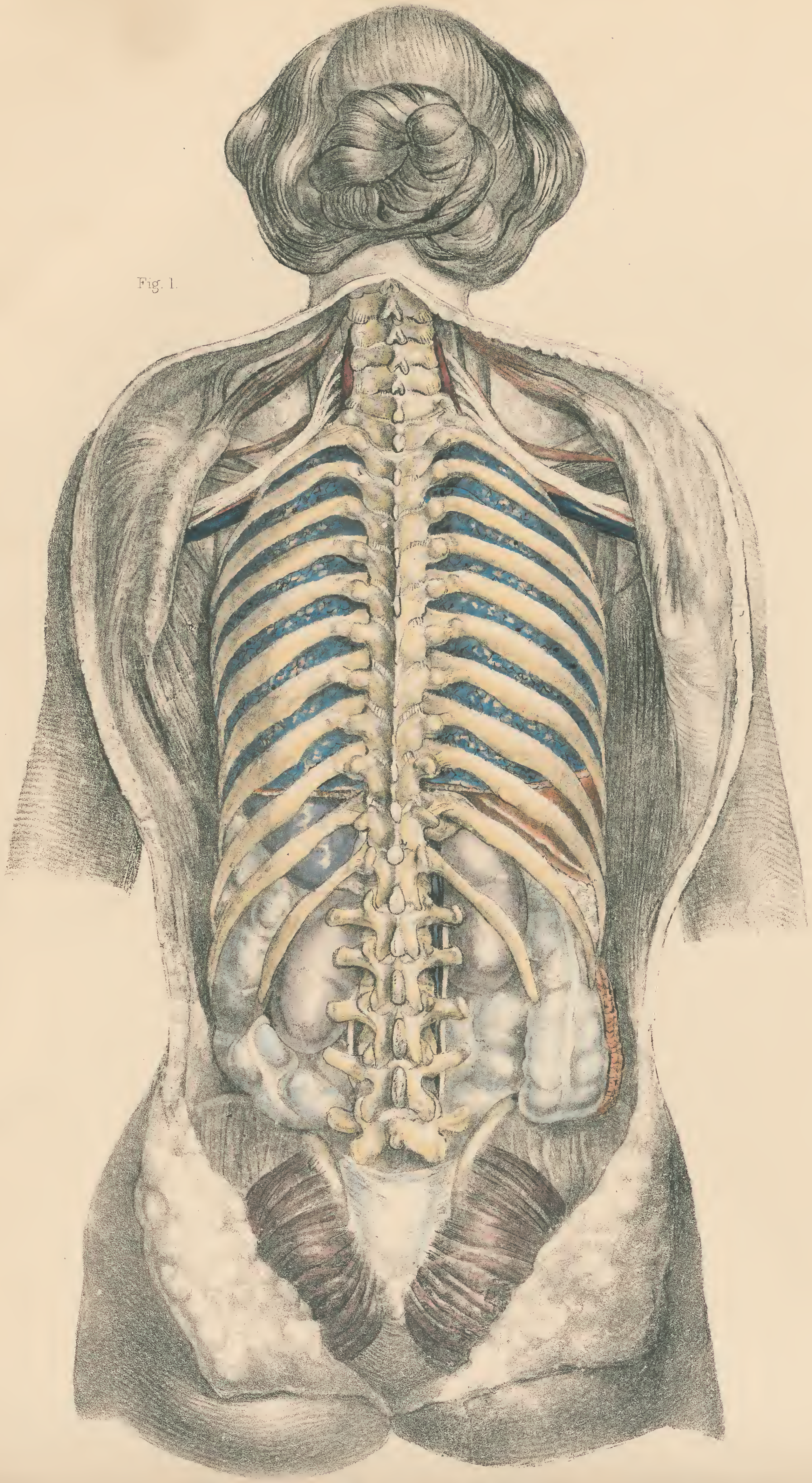
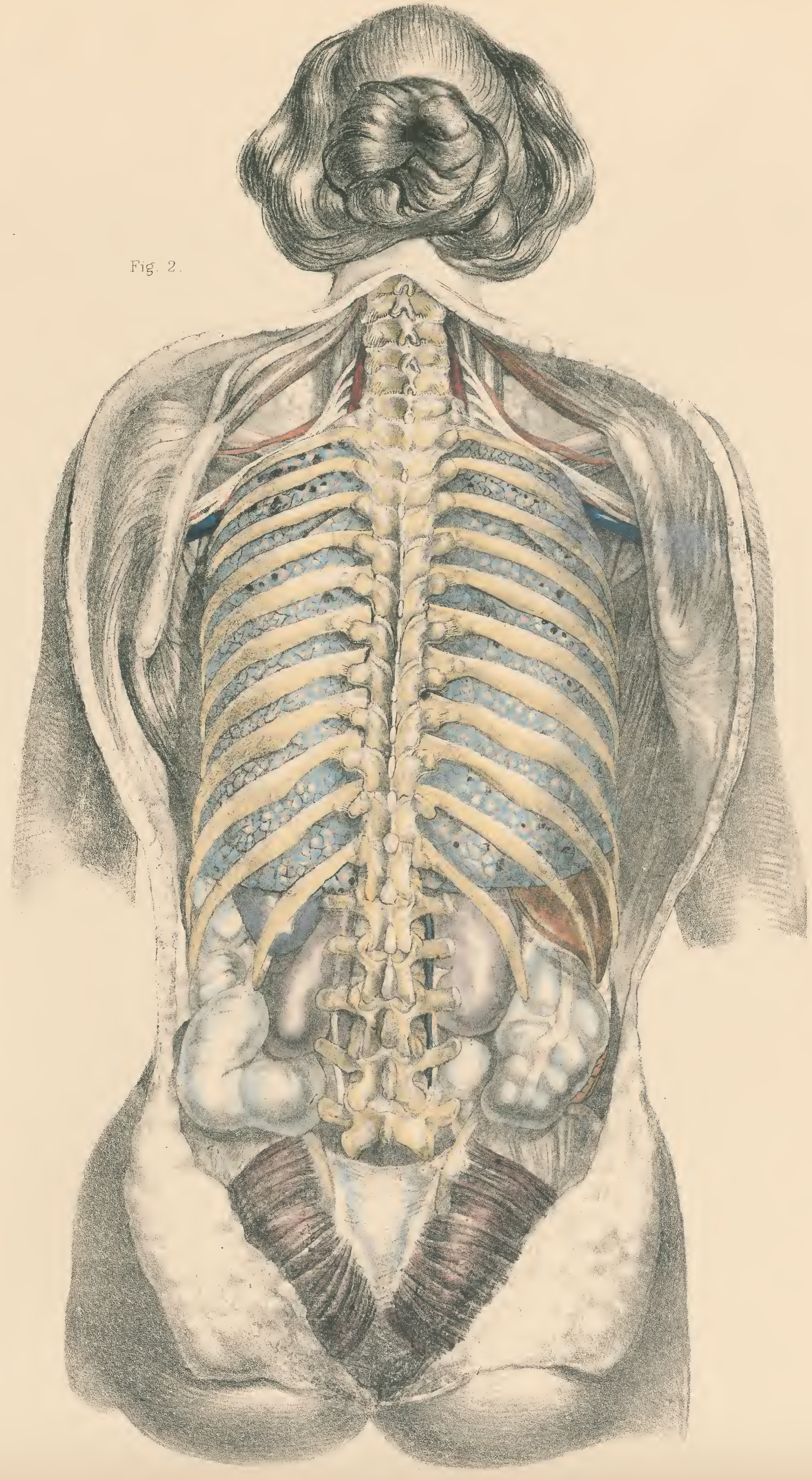


Fig. 2



intermediate viscera. This pressure causes the descent not only of the intestines freely occupying the cavity of the pelvis, but of the more attached organs also, the uterus and vagina, the rectum, bladder and prostate. The perinæum itself is subjected to the same influence. When we sit we can feel it pressing downwards on the chair if we take a deep breath. It descends, also, with considerable force during the deep inspiration which precedes and gives increased purchase to the expulsive actions from the rectum, the bladder, and the uterus and vagina.

When we view the twofold action of breathing—the inspiration by the ribs, and the inspiration by the diaphragm—we must study those two agencies separately, while we regard them as operating with combined force and mutual adjustment.

Thoracic respiration only slightly expands the lungs during tranquil breathing, but it sustains the vast atmospheric pressure that would otherwise cause their collapse when those organs are elongated by the descent of the diaphragm. It is during forced breathing that thoracic inspiration tells. Then the lungs are expanded upwards, and in their entire circumference. This inspiratory effect is expended exclusively on the lungs and, to a minor extent, on the heart. It produces no effect in altering the position of the internal organs.

Diaphragmatic inspiration is always efficient. During tranquil breathing it lengthens the lungs and heart, sustained in their circumference by thoracic expansion, and lowers the abdominal organs to the extent of about half an inch. During a forced inspiration the abdominal viscera are displaced extensively downwards by the lengthened lungs and heart, and the circumference of the abdomen is greatly enlarged. The expanding lungs completely cover the heart within the costal walls. The lungs, in fact, have the ribs and sternum entirely to themselves, the exposed portion of the heart being seated in the epigastrium.

While, then, the ribs sustain the dimensions of the lungs during tranquil, and increase them during forced inspiration, they effect no change on the position of the internal organs. The diaphragm, on the other hand, elongates the lungs and heart, and displaces the whole of the abdominal viscera downwards, during both tranquil and forced inspiration.

APPLICATION TO PHYSICAL DIAGNOSIS.

The knowledge of the effects of the respiratory movements on the external form and the position of the internal organs is the basis of physical diagnosis. I shall occupy the short remaining space with illustrations of this truth.

The movements of breathing in health are symmetrical, those of the right and left sides being equal.

In pleurisy of one entire side, the inspiratory movements of that side—the abdominal as well as the thoracic—are lessened, arrested, or reversed, those of the healthy side being exaggerated. Usually, respiration is less restrained over the upper than the lower lobe. If the disease yields, the expansion of the affected side increases—of the healthy side lessens from day to day, until the equilibrium of health is restored. If, however, empyema, or constricting adhesions follow, respiration is permanently lessened over the crippled—developed over the sound lung.

If one upper lobe is affected with phthisis or pneumonia, it expands much less than the opposite lobe. In phthisis, the movements in tranquil breathing, even over the diseased lung, are usually greater than in health, the contrast over the two sides being maintained. This contrast is especially marked during a forced inspiration, when the expansion is much less than in health. In pneumonia the movements over the affected upper lobe are almost arrested during the stage of hepatization; but they increase rapidly when the exudation softens and is expelled, the balance of health being speedily re-established.

When one lower lobe is hepatized, that lobe cannot expand, and the breathing of the healthy lung increases. The affected diaphragm is motionless, owing to its inflammation and the bedding of the solid lung into the intercostal spaces, and the corresponding abdominal movements are almost abolished; the costal, only slightly lessened. The symmetry of breathing rapidly returns with the speedy escape of the exudation.

When the entrance of air through the larynx is seriously obstructed, the walls of the thorax, especially at the lower sternum, and the epigastrium, are forced backwards by atmospheric pressure during each inspiration, while the abdomen protrudes.

In emphysema and bronchitis, the movements of the lower sternum and the epigastrium are reversed, as in laryngeal obstruction, but there is exaggerated breathing over the upper chest as well as the lower abdomen. The respiratory disturbance augments with the increase of obstruction to breathing; lessens with its diminution.

In severe pericarditis, the movements over and to the left of the lower sternum and those of the central abdomen are restrained; those of the upper ribs, exaggerated. If extensive pericardial adhesions follow, those respiratory movements are still disturbed; if not, healthy breathing is restored.

In peritonitis, abdominal respiration is at a standstill, the breathing being high and laborious at the upper part of the chest.

In some pulmonary diseases, as in phthisis, and in the emaciated and bedridden, the lungs shrink, and the body within and without presents the type of expiration. Other diseases, as emphysema, present the type of inspiration, the lungs being permanently enlarged.

In phthisis the chest is flat and narrow, the diaphragm high, the liver and stomach encroach upon the heart and lungs. The neck is long, the shoulders slope, the shoulder-blades fall and come close together. The ribs below the clavicles flatten and diverge. The nipple in relation to the ribs is high. The lower ribs sink and lengthen, and cover the raised liver and stomach. The opposite seventh cartilages converge so as to narrow the epigastrium. The lungs shrink and uncover the heart, which is raised and beats from the second or third cartilage to the fifth.

In emphysema and bronchitis, the chest protrudes, the diaphragm is low, the heart and lungs lengthen and encroach on the liver and stomach. The neck is short, the head sinks upon the chest, the shoulders are high and forward, the shoulder-blades rise, move asunder, flatten on the top, and are winged. The ribs below the clavicles protrude and converge. The nipple in relation to the ribs is low. The lower ribs rise and shorten so as to uncover the lowered liver and stomach. The opposite seventh cartilages diverge so as to widen the epigastrium. The lungs absorb the intercostal spaces and cover the heart, which is lowered, and beats only in the epigastrium. In emphysema the lower sternum and epigastrium, instead of advancing, recede during inspiration.

When one whole lung is crippled, as from constricting adhesions, the opposite lung being developed, the contracted side presents the type of expiration, the expanded side that of inspiration. On the affected side the shoulder slopes; the shoulder-blade drops close to the spine. The ribs are hollow and diverge below the clavicle, and crowd together and lengthen at the side so as to cover the stomach or liver which encroaches on the lung. The seventh cartilage comes close to the linea alba. The nipple in relation to the ribs is high. The lung shrinks, so as to uncover and draw towards it the heart, which beats more to the left or on the right side, accordingly as the left or right lung is affected. The diaphragm is high. Percussion is dull, respiration bronchial, vocal vibration feeble. The heart's sounds are loud and diffused; the respiratory movements are restrained. On the developed side the shoulder is high; the scapula is raised away from the spine. The spine is curved towards this side. The ribs converge and are full below the clavicle; diverge, rise, and shorten at the side so as to uncover the liver or stomach, which is encroached upon by the lung. The seventh cartilage diverges from the linea alba. The nipple in relation to the ribs is low. The lung expands so as to cover and displace the heart. The diaphragm is low. Percussion is resonant, respiration exaggerated, vocal vibration strong. The heart's sounds are feeble or inaudible; the respiratory movements are increased.

During expiration, the heart is exposed and raised, while the walls

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EXPLANATION OF PLATE XVIII.—BACK VIEW.

FROM THE BODY OF A FEMALE.

In Fig. I., representing expiration, the collapsed lungs come down to the heads of the eleventh ribs. Below the lungs, on the right side, the liver rests on the eighth, ninth, tenth, and eleventh ribs; on the left side the spleen rests on the four lower ribs. Those organs, the upper half of the right kidney, its supra-renal capsule, and portions of the colon, are seen through the intercostal spaces. The left kidney, in this instance, is much lower than the right; the lower half of the right kidney and a portion of the colon lie below the ribs.

In Fig. II., representing forced inspiration, the margins of the distended lungs descend below the heads of the twelfth ribs. All the abdominal organs are pressed downwards, but the liver, resting on the tenth and eleventh right ribs, the spleen, on the twelfth left rib, and a portion of the colon, are still seen through the intercostal spaces. The colon below the ribs is compressed downwards. The difference in the position of the brachial plexus caused by inspiration, as represented in this Plate, is not from actual observation.

of the chest are depressed. The impulse therefore is strengthened and raised, and the heart's sounds are intensified. In the emaciated, sedentary, and bedridden, expiration is feeble, and the average size of the lungs is lessened. The heart is therefore permanently exposed and raised as in expiration, the impulse being strong and diffused upwards; the heart's sounds, loud and extended. The action of the heart, though really weak, appears to be strong, owing to its whole force being brought to bear on the surface of the chest.

During inspiration and in the robust, those effects are reversed. The lungs cover the heart within the ribs. The exposed part of it is lowered into the epigastrium. The impulse migrates from the costal walls to the xiphoid cartilage. The heart's sounds are feeble over the front of the chest, loud below the sternum. The heart, though really strong, appears to be weak, owing to its force being masked by the interposition of the lung.

When the aortic aperture is obstructed, and its valves are patent, systolic and diastolic murmurs are both audible over the middle sternum during expiration, and if the lungs are permanently contracted; but during inspiration, and in the robust, those sounds scarcely penetrate through the thick couch of lung interposed between the aorta and the sternum. The diastolic murmur is then audible only over and to the left of the lower sternum; the systolic murmur, over the upper sternum and the great vessels in the neck. Generally in such cases, owing to hypertrophy of the left ventricle, the apex-beat is strong and low, and far to the left—sometimes in the sixth space; but during inspiration, and in the robust, the expanded lung masks the apex-beat, which ceases to be the index of the enlargement of the left ventricle.

When the mitral valves are imperfect, the systolic murmur, centreing in the apex, is higher or lower, extended or narrowed, accordingly as the lung is expanded or contracted.

In severe pericarditis with effusion, the expansion of the lung is prevented by the distension of the pericardium, the descent of the heart by the inflammation of the centre of the diaphragm. Inspiration, therefore, scarcely lessens the friction-sound, or extent of cardiac dulness on percussion, and the respiratory movement at the epigastrium is arrested. As the pain disappears, and the effusion lessens, breathing is re-established, and the friction-sound is increased and raised during expiration —lessened and lowered during inspiration.

When pericarditis attacks a person affected with emphysema, the friction-sounds are audible, not over the front of the chest, but over the xiphoid cartilage.

When pericardial adhesions are extensive, and the heart is large, the lungs are displaced, and they scarcely penetrate between the heart and the ribs during inspiration. The impulse is therefore strong, extensive, and high; it retracts between the cartilages, and is scarcely lowered or lessened in extent during inspiration. The respiratory movements at the centre of the abdomen are much lessened, owing to the adhesion of the centre of the diaphragm to the heart. These signs, the non-diminution and non-descent of the cardiac impulse, and the non-movement of the centre of the abdomen during inspiration, are the two important signs of extensive pericardial adhesions.

In Fasciculus II., column 18, I described certain cases in which a systolic murmur was heard during health over the clavicle, towards the end of a deep inspiration. This sign has been noticed since then by Dr. Kirkes in cases of phthisis. The other day, when examining a man with Mr. Part and Mr. Gowland, we heard a systolic murmur below the left clavicle during inspiration. At the end of a deep breath the murmur ceased, and the pulse at the wrist stopped. This murmur is caused by the stretching of the subclavian artery over the first rib at the insertion of the scalenus during inspiration, when the rib rises and the artery descends, as in Plate XVII. When we raised this man's arm over his head, and so took the pressure off the artery, the murmur ceased, and the pulse returned. This sign, which led in one case to the erroneous diagnosis of subclavian aneurism, is no indication of disease.

Since the liver and other abdominal organs descend and advance freely during inspiration, any tumour attached to those organs also descends and advances freely at the samè time. In thin persons such a tumour when in front of the aorta pulsates during expiration, but ceases to pulsate during inspiration, when it falls forwards away from the aorta. The abdominal aorta, on the other hand, is fixed to the bodies of the vertebræ, and the pulsation which is present in thin persons above the umbilicus disappears when the abdominal walls advance during the act of breathing. For the same reason, aneurismal tumours of the abdominal aorta which pulsate strongly during expiration, often cease to pulsate and become imperceptible during a forced inspiration.

These instances, which might have been extended, show that a sound physical diagnosis is to be made, not from the observation of any single sign, however characteristic, but from the rational study of the various signs which in their *ensemble* constitute the phenomena of respiration.

THE SIGNS PRESENT IN HEALTH OVER THE UPPER LOBES.

The following observations were made by a Committee consisting of Dr. Baly, Dr. George Johnson, Dr. Quain, and Dr. Sibson, and named by a private Society for the study of Diseases of the Chest.

The observations were made on fifty healthy men, their ages ranging from eighteen to thirty, selected by Dr. Baly from among the inmates of Millbank Prison.

(Published with the sanction of the Society.)

SIGNS OVER THE FIRST AND SECOND RIBS BELOW THE CLAVICLES.

Respiratory Movements:—Number of Observations.... 47

Equal..................	45	
Greater on the Right	1	
Greater on the Left	1	

Sound on Percussion:—

A. Over 1st and 2nd Ribs:—Number of Observations 50

Equal..................	39	Including 1 doubtful.
More resonant on the Right	4	All slightly.
More resonant on the Left	7	1 decidedly. 4 slightly. 2 very doubtful.

B. Over 1st and 2nd Cartilages:—Number of Observations 20

Equal..................	1	Others probably not recorded.
More resonant on the Right	3	
More resonant on the Left	16	7 decidedly. 9 slightly.

Breath Sound during Inspiration, ordinary:—Number of Observations 50

	Equal..................	26	13 Sound distinct. 7 Sound feeble. 3 Sound scarely audible. 1 Sound inaudible. 2 undecided as to equality.
N.B.—In one case no Sound heard on right.	Louder on the Right	7	1 decidedly. 3 slightly. 3 predominance somewhat doubtful.
	Louder on the Left	17	2 much. 6 decidedly. 8 slightly. 1 slightly, but very faint.

Breath Sound during Inspiration, forced:—Number of Observations.. 50

Equal..................	20	17 decidedly. 2 equality doubtful. 1 scarcely audible.
Louder on the Right	10	6 decidedly. 3 slightly. 1 predominance doubtful.
Louder on the Left	20	14 decidedly. 5 slightly. 1 doubtful.

Breath Sound during Expiration, ordinary:—Number of Observations.. 50

	Equal..................	28	3 distinctly. 6 scarcely audible. 19 inaudible.
	Louder on the Right	21	2 much. 7 decidedly. 10 slightly. 1 slightly, but very faint. 1 predominance doubtful.
N.B.—In seven cases no Sound heard on left.	Louder on the Left	1	Decidedly.

Breath Sounds on Expiration, forced:—Number of Observations.... 49

Equal..................	6	4 more or less loud. 1 feeble. 1 scarcely audible.
Louder on the Right	41	6 much. 23 decidedly. 12 slightly.
Louder on the Left	2	Decidedly.

Sound of Whisper:—Number of Observations 42

Equal..................	0	
Louder on the Right	42	5 much. 29 decidedly. 8 slightly.
Louder on the Left	0	

Sound of Voice:—Number of Observations 50

Equal..................	3	
Louder on the Right	47	4 much. 37 decidedly. 6 slightly.
Louder on the Left	0	

Vocal Vibration:—Number of Observations................ 50

Equal..................	3	2 distinct. 1 feeble.
Stronger on the Right	47	5 much. 37 decidedly. 5 slightly.
Stronger on the Left	0	

Heart's Sounds, especially Second Sound:—Number of Observations.. 50

Equal..................	14	
Louder on the Right	29	1 much. 21 decidedly. 6 slightly. 1 predominance doubtful.
Louder on the Left	7	3 decidedly. 4 slightly.

BREATH SOUNDS OVER THE BACK.—SUPRA-SPINOUS FOSSA.

Breath Sounds during Inspiration, forced:—Number of Observations.. 16

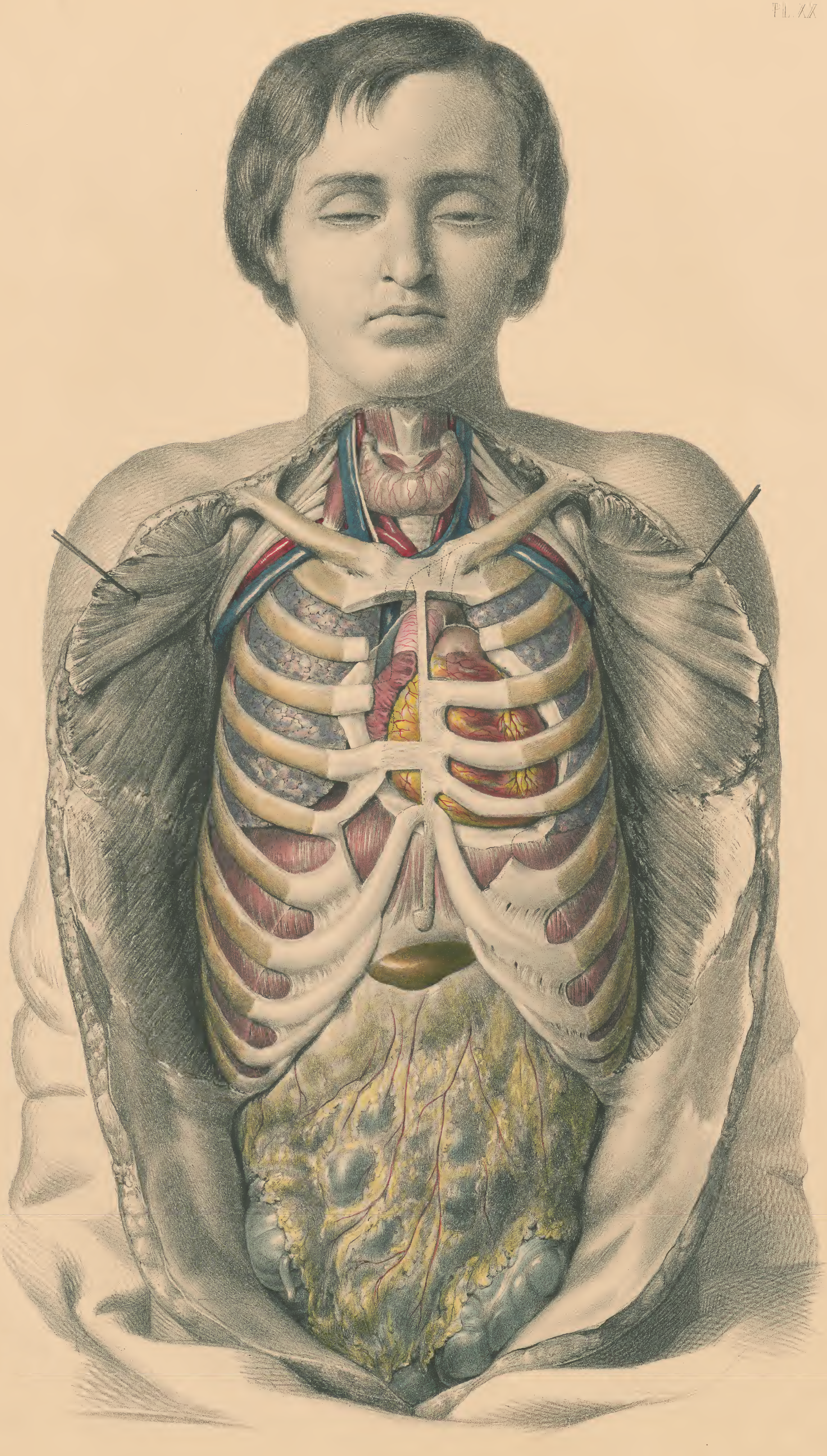
Equal..................	7	
Louder on the Right	4	Decidedly.
Louder on the Left	5	2 decidedly. 3 slightly.

Breath Sounds during Expiration, forced:—Number of Observations.. 16

Equal..................	0	
Louder on the Right	16	12 decidedly. 4 slightly.

J B LEVEILLÉ LITH.

Imp. Lemercier R. de Seine 57, Paris



J. B. LÉVEILLÉ LITH.

IMP. LEMERCIER, R. DE SEINE 57 PARIS

PL. XXI

FIG. 1

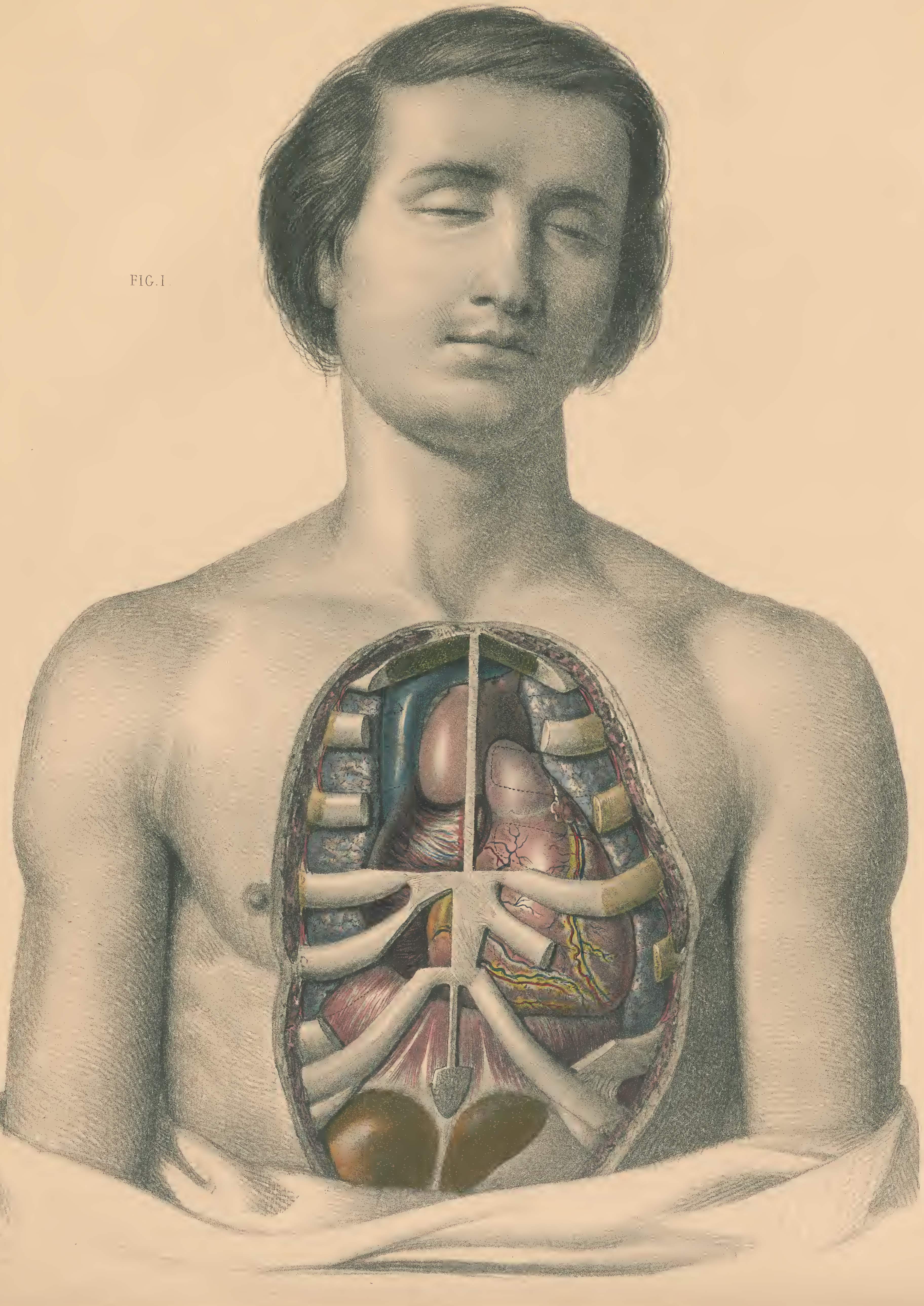
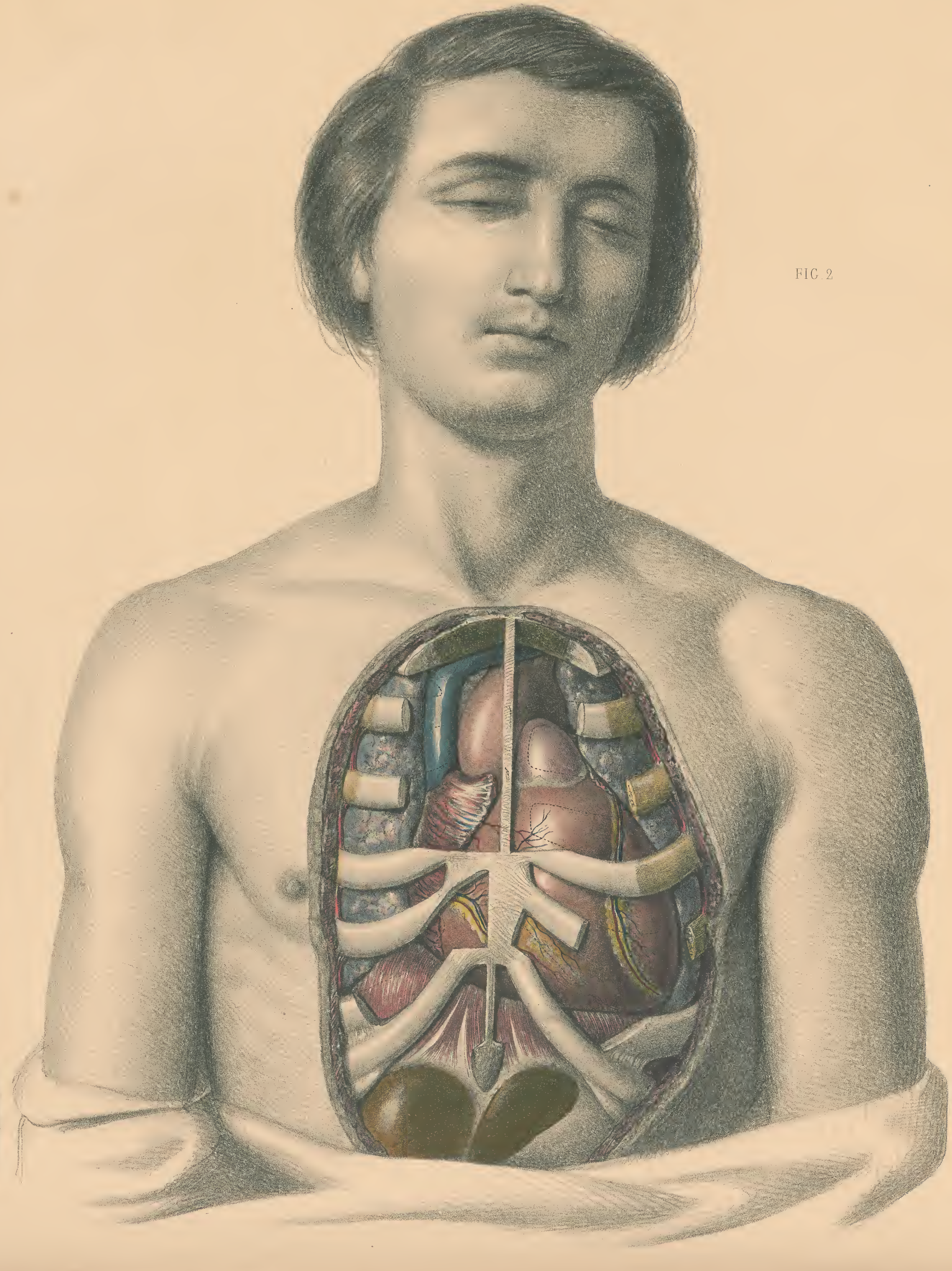


FIG. 2



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COMMENTARY ON PLATES XIX., XX., & XXI.

ON THE MOVEMENTS, STRUCTURE, AND SOUNDS OF THE HEART.

The observation of the heart in the dead body gives a very inadequate idea of its intrinsic movements and varying position during life. The organ after death almost always shrinks upwards, and as the last effort is one of expiration, the diaphragm and the heart and great vessels are unduly raised.

My last commentary contained a description of the movements of respiration, and included an account of the effect of inspiration in lowering the heart and great vessels, and of expiration in raising them.

In this concluding part, I shall endeavour to describe and illustrate the heart in motion, and give an account of the structure of the organ, especially as regards the muscular and valvular apparatus by which its movements are accomplished.

THE MOVEMENTS OF THE HEART.

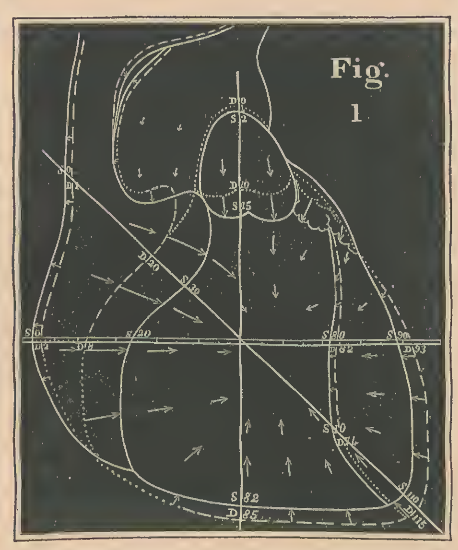
My first experiments on the movements of the heart were made upon the ass, in the year 1843, in Nottingham, when I was assisted by Mr. Shepperley. The animal was rendered apparently lifeless by means of the Wourali poison, with which I was kindly supplied by my friend, the late Mr. Waterton; and the beating of the heart, and the circulation of the blood were maintained in full force, by the aid of artificial respiration, for a period of four hours.

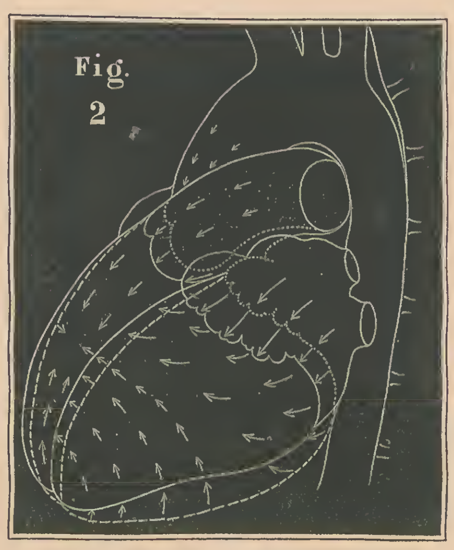
My recent experiments, in which I was assisted by that excellent observer, Dr. Broadbent, were performed on the dog and the ass, when rendered unconscious by chloroform, which was given by Mr. Edwards. Following the plan of Dr. Halford, we watched the movements of the heart through the pericardium, which was rendered almost transparent by stripping off its fatty covering.

In order that the successive movements of the heart might be observed with accuracy, a millimetre measure was stretched across the organ, as in Fig. 1, and its precise position in relation to the measure was noticed, first at the end of the diastole, and then of the systole.*

The heart, when in full action, presents to the eye the most remarkable contrasts in the size, position, colour, and form of its various cavities and great vessels. When the ventricles contract, they do so with a twisting movement, their walls become rigid and corrugated, their apex and base approximate, the descent of the base being greater than the ascent of the apex, and the arteries and veins on their surface become prominent and tortuous. The auricles become swollen with blood, and seem to push before them the retreating ventricles at the base. The great arteries are distended and lengthened, being apparently drawn downwards at their origin, by the contracting ventricles.

When, however, the ventricles expand, the aspect of all the parts is reversed. The ventricles enlarge in every direction, but especially towards the base. Their walls are flaccid, swollen, and smooth; and the arteries and veins on their surface become straight and small. The auricles shrink, becoming pale and wrinkled, and are in great part replaced by the ventricles, into which they empty their blood. The great arteries lessen in size and shorten, and ascend at their origin, being apparently raised by the upward enlargement of the ventricles.





Owing to the reciprocal contraction and distention of the ventricles on the one hand, and the auricles and great vessels on the other, the whole fluid contents of the heart and great vessels are obviously nearly the same in amount during the systole as during the diastole. The distribution of the blood, however, is different, its quantity being greater in the ventricles at the end of the systole, in the auricles and great vessels, at the end of the diastole.

The Systole of the Heart.—The contraction of the right ventricle, owing to its position at the front of the heart, and its consequent complete exposure, is marked and vigorous. Its whole right margin (Fig. 1), at the junction of the ventricle to the auricle, moves extensively from right to left; while its left margin, at the septum, moves to a comparatively slight degree from left to right. At the same time, the top of the ventricle, at the origin of the pulmonary artery, descends, while its whole lower border, where it rests on the diaphragm, ascends. These various movements converge upon a space or point of rest, situated about the middle of the ventricle, but comparatively near the septum. This point of rest corresponds with the attachment of the anterior papillary muscle.

The right auricle and vena cava are distended, and the pulmonary artery is enlarged and lengthened simultaneously with the contraction of the ventricle. The auricle, which just before was pale and wrinkled, becomes plump, glistening and purple; and its auricular portion and left edge move rapidly inwards, and to the left, so as to replace the ventricle. The movement of the auricular portion is remarkable. It suddenly enlarges and becomes purple, its tip moving from the right to the left edge of the sternum, at the level of the third costal cartilages.

The contraction of the left ventricle is only visible along its left border, including the apex, where it moves forwards and to the right, the apex having, in addition, a revolving movement upwards. The appendix of the left auricle, which is scarcely visible during the diastole, distends during the systole, and moves rapidly forwards and downwards, so as to replace the retreating ventricles, and fill up the angle between them and the pulmonary artery.

When we remove the left ribs, and look at the heart from the left, so as to obtain a view of it in profile (Fig. 2), the animal lying upon its back, we see that the whole ventricle moves forwards during the systole, the posterior wall advancing much more than the anterior; and that the base of the ventricle descends while the apex ascends, so that apex and base approximate. It is difficult to fix upon the precise point or zone of rest of the ventricular walls towards which the apex, on the one hand, ascends, and the base, on the other, descends; but it is somewhere about the middle of the ventricle—nearer, perhaps, to the apex than the base. This region of stable equilibrium corresponds to a similar point of rest in the papillary muscles. Owing to this arrangement, the ventricles and the valves adjust themselves to each other throughout the whole period of the ventricular contraction.

The left auricle, like the right, becomes swollen during the systole; when it descends and advances, so as apparently to displace the base of the left ventricle. That I might discover whether the displacement of the base of the ventricle was really caused by the distension of the auricle, I cut off the supply of blood to the auricles by tying the venæ cavæ. Both auricles soon became empty, their walls shrinking inwards. Both ventricles became smaller; but they still contracted forcibly during the systole, the base approximating to the apex, though to a less extent than when the blood circulated freely through the heart. It is, therefore, evident that the descent of the base of the ventricle during the systole is intrinsic, and not due to the displacing effect of the distending auricle, though it may be influenced by that agency.

When the left ventricle propels its contents into the aorta, its arch is distended and lengthened, and its origin, like that of the pulmonary artery, descends. The arch of the aorta enlarges both in length and breadth, and becomes tense and rigid. Its lateral enlargement is small, but its elongation is considerable, as Skoda remarks in his work "On Auscultation and Percussion," translated by Dr. Markham, page 159. There are two agencies at work in common, each of which would necessarily cause the descent of the origin of the aorta. The ventricle, by its contraction towrds its own centre, pulls down the artery at its point of attachment; and the blood acting from within, distends and lengthens the vessel, and pushes downwards the origin of the artery.

Since the auricles and great vessels enlarge in all directions during the systole, they not only descend into the place just left by the retreating ventricles, but they also enlarge outwards. The result is, that there is a greater amount of blood at the base of the heart, including the great vessels, at the end of the systole than at the end of the diastole. Since, however, during the systole, the ventricles empty themselves, the increase of the blood at the base is probably balanced by its diminution towards the apex. During the period of rest which follows the dilatation of the ventricles, the blood flows from the veins into the auricles. At its conclusion, therefore, when the auricle contracts, just before the ventricular systole, the amount of blood in the heart and great vessels is greater than at any other time.

The Lever Movement of the Ventricles during the Systole.—In all our early experiments, which were performed when the animal lay upon its back, the apex and the anterior walls of both ventricles invariably advanced during the systole. On one occasion the creature was turned upon its side, when I noticed that the anterior walls of the ventricles, instead of advancing, actually receded during the systole. I subsequently repeated this experiment again and again, in the same and in different animals, and invariably with the same result. When the dog lay upon its back, the anterior walls of the ventricles always moved forwards; when it was turned on the side, they either fell backwards or were stationary. It occurred to me, that if this

* The systole and the diastole of the heart are represented in Plate XXI., and in Figs. 1 and 2. In those figures the outlines of the cavities of the heart and the great vessels are indicated—at the end of the systole of the heart, by continuous lines, at the end of the diastole, by interrupted or dotted lines. The dotted are less accurate than the interrupted lines. The systolic movements are everywhere shown by arrows, the extent of the movements being marked by the length of the arrows. It is more difficult to watch and measure the movements of the heart at the side than at the front. The side view, Fig. 2, is therefore not so accurate as the front view, Fig. 1. I believe, however, that both figures very fairly represent the movements of the heart.

EXPLANATION OF PLATES XIX., XX., AND XXI.

Plate XIX. is taken from a robust man, who died in the prime of life, his internal organs being healthy. The heart is large and filled with blood. The lungs are well developed, the chest is ample, and the diaphragm is rather low. The heart and great vessels are very nearly in the position that they occupy during life at the middle of an ordinary inspiration.

Plate XX. represents a youth who at his death lost much blood. His heart is small and empty. His lungs have collapsed, and his diaphragm is high. The heart has shrunk upwards after death, and its position and that of the great vessels are unusually high.

Plate XXI. aims at presenting the heart in motion during life, in the opposite conditions of systole and diastole.

advance of the apex and front of the ventricles, when the animal was lying upon the back, were due to the fulcrum afforded to the base of the left ventricle, the walls advancing, as it were, by a lever movement, that the same effect would be produced if it were lying upon its side, by inserting a fixed prop or fulcrum behind the base of the left ventricle. And it was so. When I introduced a flat ruler, or my finger, behind the ventricle, so as to give it a fixed support, when the dog lay on its side, the anterior walls, which just before were stationary or receded during the systole, now advanced, just as when it lay upon its back, though scarcely to the same extent. On the frequent repetition of this experiment, which always excited my admiration, the same result followed. In order to ascertain how far this effect was due to the fluid contents of the ventricles, and how far to the rigidity of their muscular walls, I cut off the supply of blood by tying the venæ cavæ. The effect not only remained but was intensified. When, in this state, the animal lay on the back, or the prop was inserted when it lay on the side, the anterior walls advanced more than when the blood circulated freely. It was evident, therefore, that this lever movement forwards was due to the intrinsic muscular contraction and rigidity of the walls themselves, and in no respect to the blood contained in the cavities. That I might discover, if possible, the precise part of the muscular structure on which this lever movement forwards depended, I removed in succession the anterior wall of the right ventricle, the septum, and the papillary muscles of the left ventricle; and I found, contrary to my anticipation, that after each successive removal, the ventricles continued to advance when the dog lay upon its back, or when a fulcrum was introduced behind the heart, when it lay upon its side.

Before leaving this subject we must ask, upon what fulcrum does the base of the left ventricle rest when the animal lies upon the back, and the apex and anterior walls of the ventricles advance during the systole by a lever movement? That this fulcrum cannot be the spinal column is evident, for the aorta and œsophagus are interposed between the heart and the bodies of the vertebræ. Neither can it be those vitally important tubes, for they could not with impunity be subjected to forcible and ever-recurring pressure. We must look for this fulcrum to the fibrous structure of the pericardium, which is of great strength. In my paper "On the Mechanism of Respiration," in the *Philosophical Transactions* for 1846, p. 538, I stated that, "From the floor of the pericardial sac" (the central tendon of the diaphragm) "is given off a strong tendinous web that sheathes the whole pericardium, and is inserted into the investments of the great vessels at the upper part of the chest." The base of the left ventricle rests securely upon the strong fibrous pericardium, upon which it is slung as it were upon a hammock, and which is attached to the central tendon of the diaphragm below, and to the great vessels above.

The Effects of the Pressure of the Blood upon the Walls of the Ventricles in producing the Impulse.—I observed, in repeated experiments, that when the finger was pressed upon the front of the ventricles, it was lifted forwards with force, during the systole, to the extent of nearly half an inch ($\frac{45}{100}$ths.) This propulsion forwards of the finger was much greater than the forward movement of the walls when not pressed upon, as indicated to the eye, or by means of a delicate lever. When the finger was applied to the apex, and pressed gently upwards, it was pushed forcibly downwards during the systole to the extent of a quarter of an inch. This downward propulsion of the finger was the reverse of the ordinary movement of the apex during the systole, when it ascended towards the base if not thus subjected to pressure. Again, when the heart was grasped by the hand, the fingers and thumb sank into the flaccid walls of the ventricles during their dilatation, but were driven asunder with great power when the walls contracted.

What is the cause of this protrusion of the finger when pressed on the walls of the ventricle during the systole? Is it muscular rigidity? That this cause may operate is probable; but when we find that a finger pressed upon the muscles of the thigh is propelled forwards only to a slight extent when those muscles contract, we must answer, that there is some other agent at work besides muscular rigidity.

A little consideration will show that this additional agent is the counter pressure exerted by the blood on the walls of the ventricles, when the contraction of those walls drives it into the great arteries. The pressure exerted by the blood, when propelled outwards, is equal in every direction; it therefore evidently presses not only on the outlets through which it escapes, but also on the walls by which it is expelled. To use the words of Skoda, as rendered by Dr. Markham, "During the ventricular systole, the blood presses upon every part of the heart's surface with a force equal to that by which it is itself compressed." The pressure of the blood thus reacts on those walls that by their contraction propel the blood outwards. In order to test this explanation, the blood was shut off from the heart, when it was found that the finger applied to its front walls or apex was forced forwards or downwards during the systole to a much less extent than when the blood circulated freely through the heart.

The Causes of the Impulse.—It is evident, from what has just been said, that the impulse of the heart is due to more causes than one.

The rigidity of the muscular walls is one of those causes.

The lever movement, described above, and illustrated elsewhere by Ludwig, which is itself due to muscular rigidity, is another.

An additional, and probably the most important, cause of the impulse is the outward pressure of the blood in the ventricles on the walls by which it is expelled, and through those walls, on the ribs and intercostal spaces; just as the pressure of the blood produces the pulse at the wrist and the pulsation of an aneurismal tumour. The pressure of the blood is a cause of the impulse which tells invariably,

whatever may be the position of the body, which, as we have already seen, is not the case with the lever movement.

According to Gutbrod and Skoda, "the pressure which the blood exerts," owing to the contraction of the ventricles, "upon the walls of the heart opposite to the opening whence the stream escapes, causes a movement of the heart in a direction contrary to that of the stream of blood; and by this movement the impulse of the heart against the walls of the thorax is produced. The heart is driven in a direction contrary to that of the arteries, with a force proportioned to the quantity and velocity of the current of the blood." A precisely similar explanation of the impulse was given by Dr. Alderson, in the *Quarterly Journal of Science, Literature, and Arts* for 1825.

Skoda gives also the following additional cause of the heart's impulse:—"The aorta and pulmonary artery, being free and unattached to some distance from their origin in the heart, allow of a lengthening of the blood column downwards; and the heart will consequently be forced in that direction."

The two causes thus advanced by Skoda produce the impulse by the common effect of forcing the heart in a direction downwards; and they are grounded upon his view that the heart descends, "in some cases as much as one or two inches lower during the systole than during the diastole"! Now, these two agencies exist, and they tend to produce the effect described, of forcing the heart downwards. They are, however, overbalanced by the more powerful agency of the muscular contraction upwards of the lower half of the ventricle. The result is, that while the upper portion of the ventricles is lowered, their lower portion, including the apex, is raised during the systole, when the ventricles contract from all sides towards their own centres; and that practically the heart's impulse is not influenced by either of those causes.

It is to be noticed before leaving this important question, that the impulse is not a downward movement of the heart, but a propulsive movement forwards and outwards. The ventricles, in short, over their whole surface, make a direct thrust against any object upon which they impinge, and wherever, therefore, they come in contact with the walls of the chest. The impulse is concentrated at the apex, in the fourth or fifth intercostal space, or diffused over the whole front of the ventricles, in the spaces between the costal cartilages, according to the extent to which the heart is covered by the lung. When the heart is lowered by the descent of the diaphragm, and the lung interposes everywhere between that organ and the walls of the chest, the impulse is no longer perceptible over those walls, but may be felt in the epigastric space close to the xiphoid cartilage. The muscular rigidity and the lever movement of the ventricles, and above all the pressure of the blood in those cavities during the systole produce the impulse wherever the heart is in immediate contact with the parietes. When the heart is displaced to the right side of the chest, the same causes produce the same effect, and the impulse is then felt, with a propulsion not downwards, but forwards, over the right intercostal spaces.

The Movements of the Papillary Muscles.—That I might observe the action of the papillary muscles, I removed the anterior wall of the right ventricle when the heart was beating *in situ;* and I found that the tip of the anterior papillary muscle of the right ventricle contracted towards the septum during the systole.

I then removed the septum, so as to expose the two papillary muscles of the left ventricle, and I noticed that the muscles, which during the diastole were wide asunder, approached and came close together during the systole. At the same time, the tips or free ends of the muscles, with their tendinous cords, descended; while their attached ends ascended. The fixed point towards which the two ends approximated corresponded apparently to the zone of rest, or stable equilibrium, in the walls of the ventricle towards which the base and the apex of the ventricle approximate during the systole.

The Action of the Mitral and Tricuspid Valves.—In order that I might see the movements of the mitral and tricuspid valves, I cut out the heart when beating vigorously, and immersed it in water. The ventricles contracted with force, and expelled the water from the great vessels during each systole. The jet from the aorta was six inches in length. The segments of the mitral and tricuspid valves came together at their beaded margins, so as to close the valves, and prevent the efflux of any liquid. It was difficult to observe whether the valves at their outer rim, where they are attached to the muscular walls, altered in shape or size towards the end of the systole; but it appeared to me that they retained their form and dimensions, and they were certainly completely closed, throughout the contraction of the ventricles.

At the beginning of each diastole, the margins of the valves separated quickly from each other, so as to admit the flow of water into the cavities. It was evident that the valves were thus opened by the intrinsic action of the heart, and not by the pressure of the fluid from behind, since in this experiment no such pressure was exerted.

THE STRUCTURE AND MOVEMENTS OF THE VENTRICLES AND THEIR VALVES.

After death, the left ventricle is generally empty, and firmly contracted, so that it represents the completion of the systole. Sometimes, however, it is distended with blood, and in a state therefore of complete diastole. Different hearts present every stage between the complete contraction and complete dilatation of the left ventricle.

The right ventricle, on the other hand, frequently represents after death the state of diastole, rarely that of complete systole.

That I might fix the heart in the exact form that it presented in the dead body, I hardened it by immersion in spirit, the vessels having been tied so as to retain the blood. I then exposed the interior of the cavities by removing the walls or making sections. In this way I obtained a series of hearts for examination, in some

of which the ventricles were in a state of complete systole (Figs. 7, 8, 22); in others, in that of complete diastole (Figs. 4, 5, 20); while in others they were in an intermediate state (Figs. 9, 10, 21). These figures were accurately drawn by Mr. Harvey Smith, from the preparations and photographs. I intend to offer the preparations from which the figures were taken that illustrate this part to the Royal College of Physicians, in the hope that they may be placed in the Museum of the College, and so be open to inspection.

THE LEFT VENTRICLE.

When we make a cross section through the middle of the ventricles, whether they are in the state of dilatation (Figs. 4, 5) or contraction (Figs. 6, 7), we see that the left ventricle is cylindrical, while the right is crescentic in form. The septum forms the anterior concave wall of the left ventricle, and the posterior convex wall of the right.

The base of the left ventricle (Figs. 3, 4, 6) is occupied, behind, by the mitral orifice, and in front, by the aortic orifice,

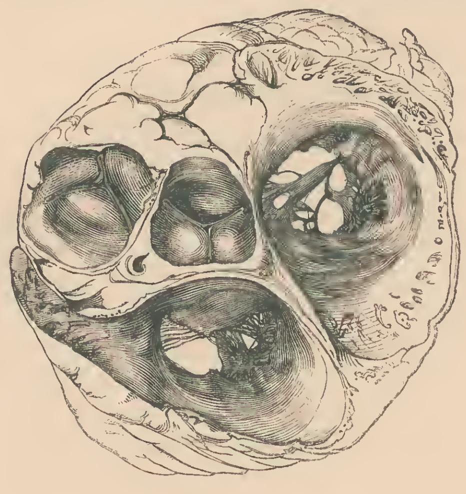


Fig. 3.

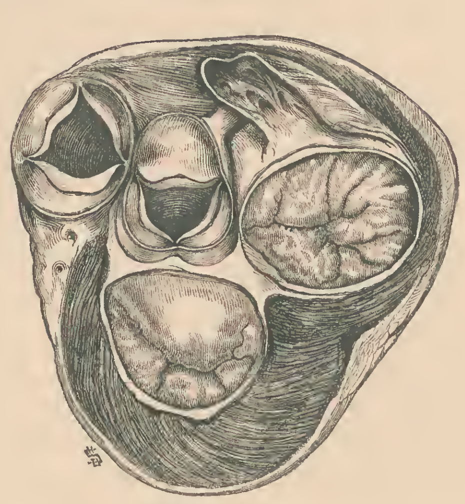


Fig. 6.

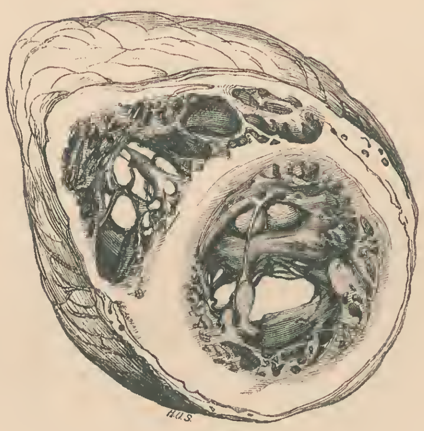


Fig. 4.

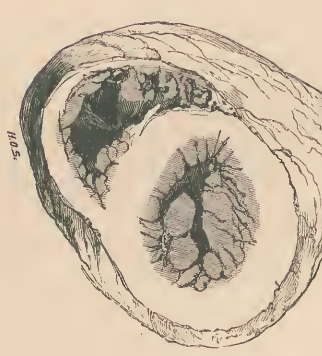


Fig. 7.


Fig. 5.


Fig. 8.

The muscular circuit of the aortic and mitral openings is in each case incomplete, those apertures being completed by a common tendinous septum (Figs. 3, 6). In consequence of this, if the heart be boiled for many hours, so as to soften out the tendinous structures, the two openings are thrown into one (Fig. 23). This tendinous septum is formed by the anterior flap of the mitral valve and by its continuation, which forms a partition between the left auricle and ventricle, on the front of which rests the two posterior aortic valves. (Figs. 3, 4, 6.) This septum, likewise, divides the cavity of the ventricle near its base, into two portions—a mitral portion behind receiving blood from the auricle, and an aortic portion in front sending blood into the aorta. (Figs. 3, 4, 6.)

The anterior or aortic portion of the left ventricle forms, when the cavity is expanded (Figs. 4, 5), an arched space, the anterior walls of which are almost smooth, and are formed by the septum and the left anterior free wall of the ventricle. The posterior or mitral portion of the ventricle is irregular in shape, being occupied by the two papillary muscles which project into the cavity, one on either side, and by the fleshy columns which interlace, so as to form a loose network of cells. This network, as it approaches the apex, surrounds the whole interior of the cavity, and assumes a spiral direction (Fig. 5.)

During the diastole, the mitral or posterior portion of the ventricle is enlarged backwards, its long axis lying in the direction of the mitral orifice (Fig. 4). During the systole, the mitral portion is gradually narrowed by the advance of its posterior walls, and the approximation of the papillary muscles and fleshy columns, the long axis of the ventricle taking the direction of the aortic orifice. (Figs. 7, 8, 12).

At the end of the systole, the cavity of the ventricle is almost obliterated by the packing together of the thickened papillary muscles, as is well seen in the cross section of the heart, represented in Figs. 7 and 8, which looks like the section of a solid muscle. (Fig. 22.) The papillary muscles and fleshy columns thus fill up the whole interior of

the ventricle, with the exception of a small triangular spiral channel (Figs. 7, 8), just behind the septum, and in the direction of the aortic opening. The spiral fibres, of which the muscular walls of the ventricle are formed, grasp, like the coils of a serpent, the vertical papillary muscles and fleshy columns during their contraction. Those muscles, consequently, fill up the cavity, and in conjunction with the contraction of the outer walls which forces them together, expel the blood in the manner described by Borelli. In consequence of this packing together and thickening of the papillary muscles and fleshy columns during the systole, the extent of the contraction of the muscular walls required to empty the cavity is materially lessened, and their expulsive force is thereby economised.

The interior of the ventricle, when seen in a vertical section (Plate VI., Figs. 9, 10) is like a hollow cone with concave sides. At the end of the diastole, when the ventricle is of full size, it is somewhat egg-shaped. Its walls are hollow, its apex is blunt, and its cavity widens from apex to base; the widest part corresponding with the tips of the papillary muscles (Fig. 4). Just above this point, at the base, close to the mitral orifice, it again contracts, leaving, however, an ample space between the posterior segment of the valve and the posterior muscular walls. The cavity contracts rapidly, and curves forward as it approaches the aortic valves, where it forms the remarkable intervalvular space

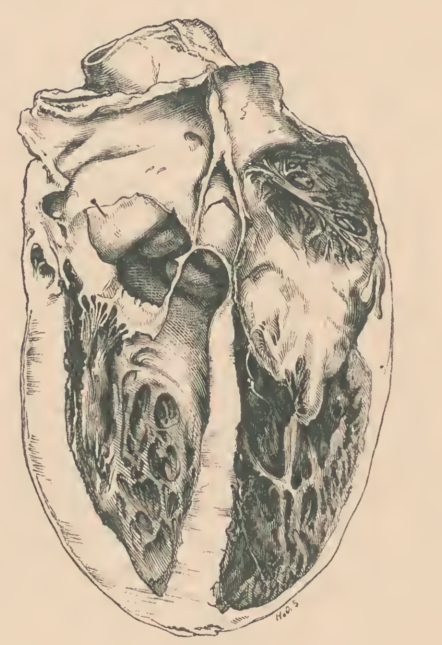


Fig. 9.


Fig. 10.

(Figs. 4, 9), which I shall hereafter describe. The two papillary muscles are as wide apart as possible. Towards the apex they join and intercommunicate with each other and the fleshy columns, so as to form the remarkable spiral network of cells just described (Fig. 5). The two papillary muscles separate from each other during the diastole in the form of a horse-shoe, the space between them being greater low down, where in one heart it was ·85 in. than higher up between the tips, where in the same heart it was ·65 in.

During the progress of the systole (Figs. 9, 10), the circumference of the whole cavity, from base to apex, gradually narrows; the walls become less concave; and a remarkable change takes place in the relations of the walls to the mitral valve at the base. While the circumference of the valve at the tendinous ring undergoes little or no diminution, the muscular walls at the base, just below the valve, contract steadily inwards, so as to present a shoulder projecting into the cavity immediately below the mitral valve (Fig. 10, B, A). This shoulder never touches the under surface of the valve, but leaves a small space in which the pressure of the blood closes the valve up to the end of the systole. The result is, that the contracted cavity of the ventricle widens outwards at the base, which is the reverse of what takes place in that region at the end of the diastole.

The cavity of the ventricle, which at the end of the diastole is somewhat egg-shaped, is totally changed in form at the end of the systole. It is then narrow and triangular, except towards the apex, where it is obliterated; and it presents a spiral twist in a direction from the aortic orifice to the apex. This spiral curve commences at the aortic valves, where it bears backwards and from right to left, is just appreciable in the body of the cavity, and becomes again marked towards the apex, where it bears forwards and from left to right* (Fig. 22). I do not, however, find that the papillary muscles assume a spiral curve during the systole; on the contrary, they lose the bend looking inwards, which they presented during the diastole, and they become perfectly straight, being parallel to, and all but in contact with each other (Figs. 7, 12, 22.) Towards the apex, however, the papillary muscles and fleshy columns curve forwards and to the right (Fig. 8, 22). The spiral curve of the left ventricle during the systole corresponds with the spiral direction of the aorta.

The Central Fibro-Cartilage or Tendinous Septum.—The fleshy septum of the ventricles terminates at the base in a strong tendinous aponeurosis, or fibro-cartilage, which performs a part of great importance in the structure and mechanism of the heart. This tendinous termination of the septum is beautifully seen in the preparation from which Figs. 9 and 10, representing a vertical section of the heart, have been taken. The muscular septum (D) is, in fact, converted at this region into

* In my paper on the Situation of the Internal Organ ("Prov. Med. Trans.," 1844, p. 518), I thus describe the systolic movements of the left ventricle. During the systole, "the cavity changes its place, being more to the right, and with its axis, which was formerly in the direction of the auricle, now pointing to the aorta. The contraction proceeds in a twisting manner; the blood is, as it were, wrung out of the cavity, and with a current that takes naturally the twisted direction of the spring and arch of the aorta."

a tendinous septum; but while the muscular septum separates the two ventricles, the tendinous septum separates the left ventricle from the right auricle, and finally the two auricles from each other. This fibro-cartilaginous septum corresponds with the central fibro-cartilage and bone of the heart of the ox, and I possess one human heart in which it is converted into bone. It may be seen in Fig. 6, that this fibro-cartilage is intimately attached to the right posterior sinus of the aorta, to the tendinous ring of the mitral orifice, to the tendinous ring of the tricuspid orifice, to the central angle of the mitral valve, especially its anterior segment, and to the central angle of the tricuspid valve. It also gives insertion to numerous muscular fibres from the right ventricle, the left ventricle and the septum, and origin to muscular fibres which go to the right and left auricles, and the inter-auricular septum. The connections, in fact, of this great central tendon are universal. It binds all these important parts together, and gives to them unity, mutual inter-dependence, and correlation of action.

The Intervalvular Space.—The left ventricle, as I have already said, curves forwards and to the right, as it approaches the aortic aperture. There it forms a chamber or space of remarkable interest which I have called the intervalvular space, situated between the aortic valves in front, and the anterior cusp of the mitral valve behind. This space is beautifully shown in the preparation from which Fig. 9 is taken, and in which the aortic valves are seen through an opening, cut in the anterior flap of the mitral valve, and the continuous wall of the left auricle. Its immediate walls are everywhere rigid and aponeurotic, and it cannot therefore be compressed by the contraction of the muscular walls during the systole. The aortic valves, during the diastole, play directly into this space, and owing to its existence the mitral valve is closed up to the end of the systole by the pressure of the blood on its anterior flap. The inner or right boundary of this space is formed by the central fibro-cartilage, or tendinous septum, just described; the anterior and left, or external boundary, by the muscular walls of the ventricle, which are there lined by a rigid aponeurosis; and the posterior boundary, by the anterior flap of the mitral valve and the continuous wall of the left auricle, upon which the two posterior sinuses of the aorta are implanted.

The Mitral Valve.—When the closed mitral valve is looked at from the auricle (Figs. 6, 11), its outline resembles that of a horse-shoe or Saracenic arch. The valve is set in the muscular structure of the left ventricle, and its base, which is tendinous, is situated immediately behind the two posterior aortic sinuses, and stretches from the left or external to the right or central fibro-cartilage (Fig. 6). This tendinous base, which is continuous with the mitral valve, forms a portion of the walls of the left auricle.

The mitral valve presents two segments or flaps, an anterior and a posterior. The posterior segment, which is crescentic in form, is set in the muscular walls, and fills up the two posterior thirds of the mitral orifice. To enable it to do so with perfect adaptation, it is divided into three sub-segments. The anterior segment, which is shaped like a half-moon, is attached to the membranous structure at the base of the valve, and it fits like a lid into the posterior or crescentic segment, which forms a frame for its reception, so as to close the valve. When the valve is shut, the central, the left, and the right sub-segments of the posterior or concave flap are opposed, respectively, to the middle, the left, and the right portions of the anterior flap (Fig. 6). The three sub-segments, where they meet, form two angles, which are filled up by the corresponding angles of the anterior flap.

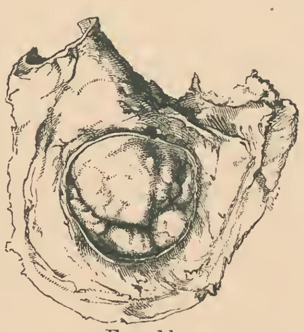


Fig. 11.

The lips of the closed valve at the meeting of the two segments are beaded (Fig. 6, 11), and its upper surface presents small rounded prominences. These prominences, as Skoda pointed out, are caused by small pouches, or sacculi, on the under surface of the valve. These sacculi are formed by the meeting together of the fan-shaped expansions by means of which the tendinous cords are inserted into the margins and under surface of the valve. This structure is beautifully seen on the anterior segment. The tendinous cords are distributed to that segment in four rows (Fig. 12), the two outer rows being attached to its margins, the two inner ones to its under surface. These rows are arranged so as to form three arched spaces, the central space being the widest. This arrangement is well seen in the preparation from which Fig. 12 is taken, in which it presents the appearance, as it were, of the nave and aisles of a Gothic cathedral.

Fig. 12.

The tendinous cords are distributed to the crescentic or posterior segment of the mitral valve in two rows, an outer and an inner (Figs. 13, 16, 17). These rows are inserted by fan-like expansions; the inner row into the margin of the segment, the outer into its under surface, about mid-way between its margin and the muscular walls, to which the posterior segment is attached. Where the cords of the outer row meet each other at the top, they form a range of pointed arches, around the outside of the valve (Figs. 13, 16, 17). Just above this range of arches the posterior segment of the valve turns over at its rim, to be attached to the tendinous ring; and it thus forms a vaulted space between the base of the valve and the muscular walls (Figs. 16, 17).

Fig. 13.

The distribution of the tendinous cords to the angles is different from that to the flaps of the valve. The anterior segment, and the central portion of the posterior segment of the valve, receive at their margins and on their under surfaces two converging sets of cords, one set from the right, the other from the left papillary muscle (Figs. 3, 4, Plate VI). The cords, on the other hand, that are attached to the inner or right, and the outer or left angles of the valve, spring, from the longest and outermost tip of the corresponding papillary muscle (Figs. 12, 13, 16, 17); and are inserted by a divergence or radiation of cords into the angle formed by the meeting of the anterior and posterior segments (Figs. 3, 4, Plate VI). Each of the angles formed between the central and two lateral subdivisions of the posterior segment receives also a set of diverging cords, that radiate from one papillary tip. (Fig. 17). This arrangement of the convergence of the cords towards the centre of each cusp, and their divergence towards the angles where the segments meet, is needful for the perfect adjustment of the lips and angles of the valve.

All round the base of the valve, between it and the muscular walls, there is, as I have just described, a vaulted space, which becomes gradually narrower during the progress of the systole; but which is never, even at its very end, obliterated. During the contraction of the ventricle, as I have already stated, a shoulder of the muscular walls projects inwards all round the base. Between this shoulder and the under surface of the valve, a distinct space exists, so that the shoulder never touches the under surface of the valve itself (Figs. 10, 11 A, B). A thin layer of blood intervenes to the very last between these opposing surfaces, so as to secure the pressure of blood upon the whole under surface of the valve, and its consequent closure throughout.

This distribution of the cords to the flaps of the valve holds them down, when, like sails bellied by the wind, they are pressed upon by the blood during the contraction of the ventricle, in the manner first pointed out by Lower.

If the cords were distributed to the margins only of the valve, as in Fig. 14, the bellying of the under surface of the flaps, caused by the pressure of the blood, would lead to the separation of their edges, and the regurgitation of the blood.

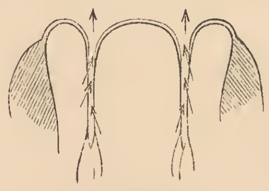


Fig. 14.

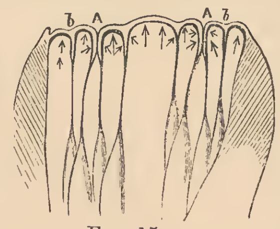


Fig. 15.

Owing, however, to the distribution of the cords to the under surface, as well as the margins of the valve, so as to hold them equally downwards, and the formation thereon of many small pouches or sacculi, as in Fig. 15, the blood, during the contraction of the ventricle, is forced into these pouches, so that they are each filled to distention. The adjoining pouches being all of them distended, and held down by the cords, necessarily displace each other outwards, so as to widen the whole area, and enlarge the circumference of the valve, in the manner represented in Fig. 15. The lips of the two segments of the closed valve are sacculated on their inner surface, and present, therefore, beaded margins, when looked at from the auricle (Figs. 6, 15 A A). When the bead-like sacculi of the lips are distended during systole, they dovetail into each other, so that the opposite margins fit together with the greatest accuracy. The sides of the lips are pressed together by the distention of their sacculi during the systole, the firmness with which the valve is closed being proportioned to the force with which the ventricle contracts so as to distend the sacculi. At the same time the whole surface of the valve is held down and flattened by the tightening of the cords (*b*). These beaded margins are thus pressed against each other, so as to shut the valve by the contact, not of their mere edges, but of their vertical sides, in the same way that the semilunar valves are closed, or that the mouth is shut by the contact of the lips (Figs. 6, 11, 15A).

When I observed the heart acting vigorously under water, after being cut out, it seemed to me that the circumference of the shut valve did not lessen with the diminution of the ventricle towards the end of the systole. It would appear, in fact, that the pressure of the blood by filling the sacculi on its under surface unfurls, flattens out, and enlarges the valve so as to maintain it almost of the full size up to the end of the systole. Indeed, any material diminution of the valve would necessarily cause it to fly open, and so lead to the regurgitation of the blood from the auricle into the ventricle, through the mitral orifice.

The Papillary Muscles.——Sometimes the papillary muscles are concentrated into two single muscles, an external or left, and an internal or right (Fig. 16), each of which presents a row of papillæ. More often they are distributed into two great groups of papillary muscles, a left and a right group, which are distributed to the corresponding portions of the valve (Fig. 4). In many hearts the two groups are united posteriorly, by a series of intermediate muscles; the posterior ones being comparatively short (Figs. 12, 13, 17). In such instances they are placed round the two posterior thirds of the ventricle, just within the muscular walls. The muscles, and the tendinous cords which connect them to the valve, are arranged within the muscular walls of the ventricle in crescentic rows, which correspond with the crescentic form of the posterior segment of the valve (Figs. 6, 11, 12, 13, 17).

Whatever be the distribution of the papillary muscles, whether there be two single muscles (Fig. 16), two groups of muscles (Fig. 4), or a

crescentic row of muscles (Figs. 12, 13, 17), it is convenient to speak of them as two, the left or external, and the right or internal.

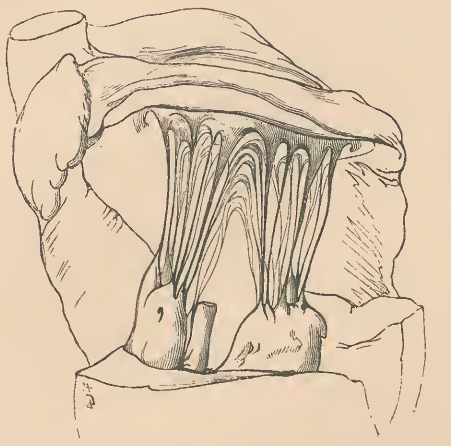


Fig. 16.

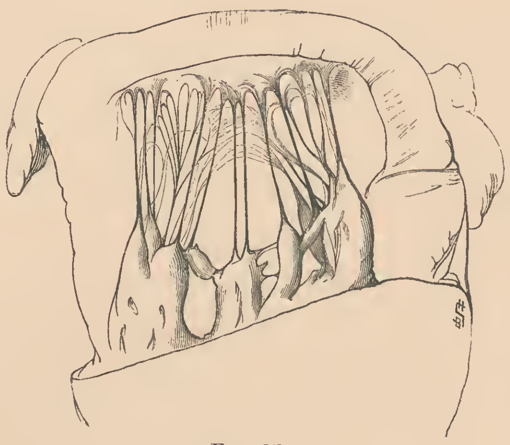


Fig. 17.

Whether the muscles are simple or compound, the principle of their arrangement and distribution is alike in different hearts. Each muscle presents, at its extreme point, a lengthened peak or papilla, with radiating cords to the corresponding angle of the valve, which are short, so as to restrain its movement. The intermediate papillary muscles, or papillæ, become gradually shorter, and towards the centre of the valve, where its segments enjoy the greatest play, the shortness of the muscles is compensated for by the greater length of the cords; while at each angle, where the movements of the valve are restrained, the length of the muscle makes up for the shortness of the cords (Fig. 17). As a rule, the external or left papillary muscle is more massive than the right or internal.

I have already described the mode in which the two papillary muscles communicate with each other, and become subdivided into and intermingle with the fleshy columns as they approach the apex (Fig. 5), where they combine to form a beautiful spiral network of cells.

During the systole, when, as we have seen, the papillary muscles and fleshy columns are packed together so as to fill the cavity of the ventricle, the right and left papillary muscles double upon each other, so as to present in a cross section, not a crescent, as during the diastole (Figs. 4, 17), but two oblique parallel rows, which fit into each other (Figs. 7, 8), as may be readily seen by making a section of the calf's heart.

The Influence of the Papillary Muscles in Opening the Valve during the Diastole.——As soon as the muscular walls relax after the end of the systole, the two papillary muscles move as far from each other as possible. In doing so they open the valve, by stretching and so drawing forward its anterior flap. When the diastole is complete, the anterior flap is held taut between the two papillary muscles (Figs. 3, 4); so that at this period the mitral orifice is fully open. I watched the opening of the valve, when the heart was beating with full force under water, and observed that the flaps separated at the beginning of the diastole, not by the pressure of the water, for no such pressure was exerted, but by the intrinsic movement of the valve itself. I believe that the stretching forwards of the anterior segment of the valve, by means of the moving asunder of the relaxed papillary muscles in the manner that I have just described, is an adequate explanation of the automatic opening of the valve.

THE RIGHT VENTRICLE.

Comparison between the Right Ventricle and the Left.—The right ventricle differs in many important features from the left. The septum, which is the party wall of the two ventricles, properly belongs to the left. How completely the septum is appropriated by the left ventricle at the base is well seen in the preparations from which Figs. 6, 9, and 10 are taken. The right ventricle is shorter from base to apex than the left, the shortening being chiefly at the base. The tricuspid valve and the base of the right ventricle are about half an inch lower, or nearer to the apex, than the mitral valve and the base of the left ventricle. The base of the left ventricle, therefore, appropriates to itself exclusively the upper or aponeurotic portion of the septum, which completes the circuit of the mitral orifice on its inner or right side. The result is, that the septum at the base is not interventricular, but is situated between the left ventricle and the right auricle (Figs. 6, 9, 10 D).

The right ventricle is then, so to speak, an abutment of the left ventricle. It is built upon the septum, which forms its borrowed posterior wall, and projects forwards into its cavity. The antero-inferior free wall is the only proper wall of the right ventricle. The anterior portion of this proper or free wall is situated immediately behind the lower costal cartilages and sternum, while its inferior portion rests upon the diaphragm. While this proper wall is convex without, concave within, the borrowed or party wall is convex within.

The right ventricle is compelled to adapt itself to the form and movements of the left, and it is therefore more complicated than the left. Various peculiarities in structure are implanted, therefore, on the right ventricle, when compared with the left, which all turn upon this, that the left is the principal, the right, the supplementary cavity.

The left ventricle, in a state of expansion, is cylindrical in form, in a cross section, while the right is crescentic. The left ventricle is egg-shaped, while the right is pyramidal, the top of the pyramid being formed by the pulmonary artery, while its base, prolonged to the left (Figs. 19, 20, 21, 22), rests upon the central tendon of the diaphragm.

In the left ventricle, the aperture of entrance through the mitral orifice is contiguous to the aperture of exit at the aorta, the two orifices being separated by a membranous septum. In the right ventricle the aperture of entrance, through the tricuspid orifice, is at a

distance from the aperture of exit at the pulmonary artery, the two orifices being separated by the muscular channel of the *conus arteriosus*. In the left ventricle, the current of blood inwards, which descends during diastole behind the anterior segment of the mitral valve, is parallel in direction to the current of blood outwards, which ascends during the systole in front of that segment (Fig. 18). In the right ventricle, the current of blood inwards is at right angles to the current of blood outwards, since the blood enters the cavity

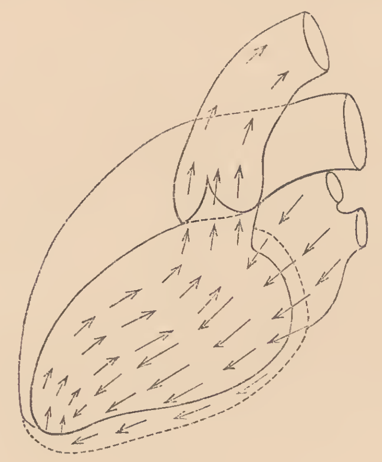


Fig. 18.

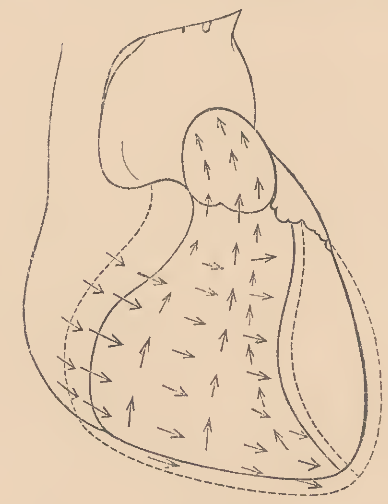


Fig. 19.

from right to left, and leaves it from below upwards (Fig. 19). During the systole, the stream of blood in the left ventricle takes a spiral direction towards the aortic orifice, in accordance with the spiral direction of the aorta itself (Fig. 18). The stream of blood in the right ventricle, as it ascends, mounts over the bulging septum, being restrained by the concave free walls. This upward stream, which narrows as it proceeds, thus takes the curved direction upwards, backwards, and inwards of the *conus arteriosus* and the pulmonary artery. In the left ventricle, the anterior segment of the mitral valve, and the right and left papillary muscles, form a hollow channel for the stream of blood, which, as it ascends to the aorta, presses upon the under surface of the valve. In the right ventricle, the stream of blood, as it ascends, sweeps onwards at right angles to the under surface of the tricuspid valve, and rushes between and across the papillary muscles, and through the tendinous cordage that connects those muscles to the valve (Figs. 19, 21).

The Tricuspid Valve.—The structure and action of the tricuspid valve and its papillary muscles are, in principle, the same as those of the mitral valve and its papillary muscles. Owing, however, to the difference in the form of the two cavities, in the relative position of their two orifices, and in the direction, inwards and outwards, of the stream of blood in the two ventricles, many important differences are implanted upon the tricuspid valve, when compared with the mitral.

The closed tricuspid valve, looked at from the auricle (Fig. 6), is irregularly oval; being large and rounded in front and below, slightly concave towards the septum, and angular behind and above, where it is attached to the central fibro-cartilage, close to the right posterior aortic sinus. The valve itself is subdivided into three great cusps: the anterior, the posterior, and the inferior. The inferior cusp, which is the largest, is deeply subdivided into several segments. Two of these sub-segments are very long and narrow; their length being twice their width. Each of them has a series of tendinous cords, which are inserted into the centre of the sub-segment from the tip to the base, in addition to a series of cords to each edge (Fig. 20, *d*). The length of these sub-segments, which meet with each other, and with the anterior and posterior cusps at a common point, about the centre of the valve (Fig. 6), is due to the great breadth of the tricuspid orifice at that region, which corresponds with the angle formed by the meeting of the anterior and inferior aspects of the free wall. For the same reason, the tips of the middle or anterior papillary muscle (Figs. 20, 21, 22, F), project into the centre of the cavity; and those of the lower papillary muscle do the same, though not to the same extent. To afford an advanced basis of support for these papillary muscles, as well as to thicken the walls, without materially diminishing the cavity and solidifying the walls themselves, a remarkable many-celled structure, made up of the net-formed meeting of numerous fleshy columns, fills up the angle between the anterior and inferior surfaces of the free wall of the ventricle (Figs. 4, 5, 20). This many-celled structure completely occupies the cavity of the ventricle in the neighbourhood of the apex. Thence the structure extends in two directions; towards and up to the tricuspid orifice on the one hand, and on the other, towards the pulmonary artery, so as to occupy the angle formed between the septum and the anterior walls.

The series of central cords which are attached to the tips of the prolonged sub-segments of the lower cusp (Fig. 20, *d*), as well as to the middle of the posterior cusp (B), while they permit those tips to meet at the centre of the valve, retain them there in exact adaptation, when the valve is closed during the systole (Figs. 6, 21).

The superior deep angle of the valve, which is implanted, so to speak, upon the aponeurotic structure of the septum, close to the right posterior aortic sinus, is guarded by two small sub-segments (Figs. 3, 6, 20 *n*), which are situated between the anterior and posterior cusps, and which present a complete contrast to the elongated sub-segments of the lower cusp. These sub-segments are short, and have very little play, being tied closely down by short tendinous cords, which spring immediately from the adjoining wall, or from very short papillæ. They are thus fitted to the very restricted angle between the anterior and posterior cusps, which they fill up and close during the systole (Fig. 6).

The upper border of each of the two superior cusps, the anterior and the posterior (A, B), which taken together are about equal in size to the inferior cusp (Fig. 6), are supplied with a series of cords, which spring directly from the posterior wall of the ventricle, or from short papillæ. These papillæ and cords combine to form the superior papillary muscle (G) which is in great part latent, being incorporated with the muscular structure of the septum.

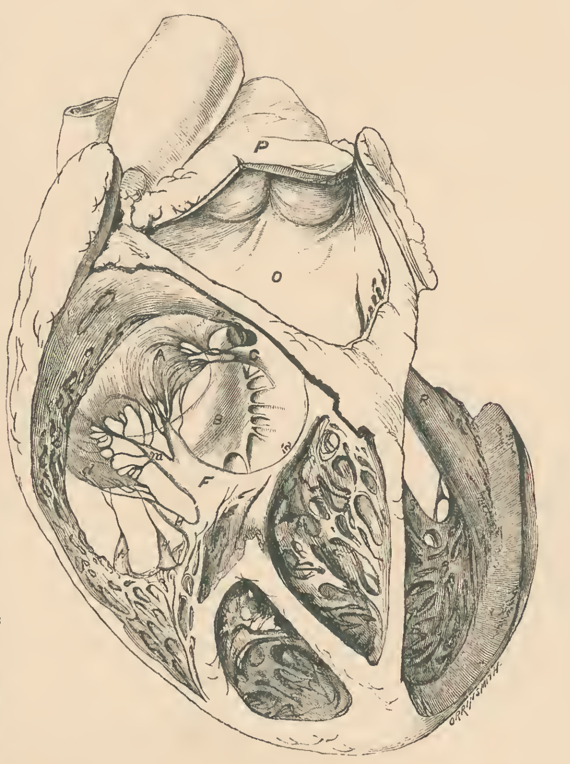


Fig. 20.

The three papillary muscles, of which I have just spoken, the superior (G), the middle or anterior (F), and the inferior (H), are so arranged as to be placed each of them between two adjoining cusps. The superior muscle is distributed, as I have just said, to the upper edges of the anterior and posterior segments; the middle muscle, to the lower edge of the anterior cusp, and the upper edge of the inferior or compound cusp; and the inferior papillary muscle, to the lower edge of the posterior cusp, and to the upper edge, and various sub-segments of the inferior cusp (See also Figs. 3, 4).

In the tricuspid valve, the distribution of the cords to the segments, though so different in detail, is the same in principle as in the mitral valve. The angles between the segments are supplied by the diverging cords radiating from one elongated papilla (*m*), while the flap of each segment is supplied by cords which converge from two distinct papillary muscles or papillæ, upon its upper and lower, or its anterior and posterior edges respectively (Fig. 20, F, A, G).

The Movements of the Right Ventricle.—The difference between the cavity of the right ventricle in a state of complete dilatation (Fig. 20), and in that of complete contraction (Fig. 22), is striking. It is difficult to recognise that it is the same cavity in the two opposite states of dilatation and contraction. The cavity during the middle of the systole (Fig. 21),* presents an intermediate approximation to the two opposite states of expansion and contraction (Figs. 20, 22).

I have already described the external movements of the right ventricle. I may, however, repeat them here in a few words. The ventricle contracts during the systole from side to side, to the extent of three-eighths of its diameter, towards a common point of rest, which is near the septum. The movement of the auricular border to the left, is six times as great as that of the septum to the right. The upper and lower boundaries of the ventricle approximate, the descent of the upper boundary and the pulmonary artery being greater and more constant than the ascent of the lower boundary, which rests on the central tendon of the diaphragm (Fig. 1). In short, the ventricle contracts from all sides towards a common centre, which is situated at the attachment of the anterior papillary muscle (F).

During the systole, the fleshy columns which form so extensive and remarkable a network at the end of the diastole (Fig. 20) shorten, approximate, and at length come into close contact. The many-celled structure (Fig. 20) contracts, driving the blood out of its meshes, and finally disappears, being replaced by solidified and thickened walls (Fig. 22). The septum or posterior wall bulges forwards into the cavity, while the antero-inferior free wall contracts in every direction. The arterial cone is greatly narrowed, flattened, and shortened. The walls close in from all sides upon the tricuspid valve. As they do so, a shoulder projects into the cavity at the base which never touches the valve, but leaves a space in which the blood continues to press upon its under surface, so as to close the valve up to the end of the systole (Fig. 10, C). It may be seen, by studying Fig. 22, that the right ventricle makes a twisting movement in the neighbourhood of the apex, owing to the great extent to which the papillary muscles and the network of the fleshy columns close in upon each other at that portion of the ventricle.

During the diastole, the papillary muscles are wide apart, and their tips diverge from each other, and look towards the base of the ventricle (Figs. 3, 20 F, G, H). The result is, that the flaps of the valve are drawn outwards and downwards towards the walls of the cavity, so that the tricuspid orifice is thrown wide open, its valve being incapable of closure. During the systole, the papillary muscles approximate, and their tips converge towards the middle of the valve, so as to permit of the approximation and contact of its flaps, and its consequent closure (Fig 21). At the end of the systole, the middle and the inferior muscles shorten and group into a mass (Fig. 22, F, H), the superior muscle (G) being still somewhat apart.

The papillary muscles contract throughout the systole, so that at the end of it they are materially shortened (Fig. 22, F). The tip and the base of attachment of each papillary muscle approximate. The tricuspid valve and the tips of the papillary muscles move with equal steps towards the apex and the septum, at the same time that the apex, the septum, and the attachments of the papillary muscles move towards the base. All the parts of the cavity and the tricuspid valve are thus maintained in a state of perfect adjustment through the whole period of the systole, the closure of the valve corresponding with the contraction of the cavity.

* The preparation from which Fig. 21 was taken represents the mitral and tricuspid valves in a state of perfect closure; in this preparation, the cavities were injected with size, so as to close the valves. The heart was then hardened by being steeped in methylated spirit, and the cavities were cut open in the manner represented in the figure. Dr. Pettigrew injected plaster of Paris, so as to close the valves, into the hearts from which the drawings were made that illustrate his paper on the valves of the heart. By substituting size, the cavities can be cut open after their walls are hardened, so as to display the internal mechanism of the valves.


Fig. 21.

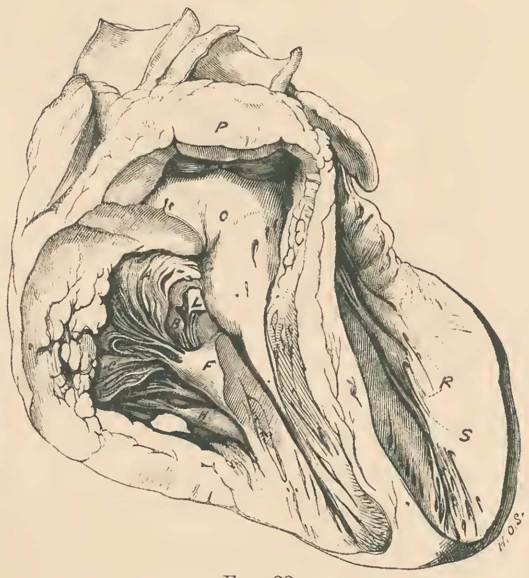


Fig. 22.

THE MUSCULAR AND TENDINOUS STRUCTURES OF THE HEART OF THE COW.

From the days of Lower, Senac, and Wollff, to the present time, the muscular structure of the heart has been examined in successive layers, from without inwards, each layer being stripped from the subjacent one. These observers all agree that the outer layers of fibres take an oblique direction from right to left, that the inner layers take a cross direction from left to right, and that the intermediate fibres run transversely. The varying direction of the fibres is admirably described by Weber, in his classical edition of Hildebrandt's "Anatomie;" and is beautifully shown in the valuable paper of Dr. Pettigrew.

This cross direction of the inner, in relation to the outer fibres, which exists throughout the whole heart, is found also in each portion of the heart's walls. Thus Ludwig has shown, in his important memoir on the ventricles of the heart (Henle's "Zeitschrift," vii, 193), that in every piece of the walls of either chamber, the fibres on the inner surface take a cross direction to those on the outer surface, the intermediate fibres taking, in regular order, a corresponding change of direction.

While inquiring into the muscular and tendinous structures of the heart, I employed three methods, in addition to that just alluded to.

By the first of these plans, either ventricle was laid directly open by a section through its anterior wall, and its papillary muscles and walls were examined from within outwards. (Figs. 24, 25, 26.)

In the second method, the fibres were unravelled in successive layers from without inwards, the layers overlapping each other in the manner shown in Figs. 27, 28. Each layer was traced from its right to its left extremity, and from the outer towards the inner surface of the heart.

The third plan was that followed by Mr. Savory, of making a series of sections through the walls and tendinous structures of the heart.

The Tendinous Structures of the Heart.—The tendinous structures at the base of the heart, as Lower, John Reid, and Ludwig have shown, give attachment or insertion to the numerous muscular fibres of the walls of the ventricles. These tendinous structures, which I shall briefly describe in successive order, are all firmly connected together, and they rest upon, surround, and support the various great orifices of the ventricles.

1. The great central fibro-cartilage (Fig. 22, A A) is situated upon the septum, with which it is incorporated, between the mitral and tricuspid orifices, and behind the right posterior sinus of the aorta. It gives insertion to very numerous muscular fibres from both ventricles, and origin to many fibres to both auricles.

2. The left fibro-cartilage (B), which is much smaller than the central fibro-cartilage, is seated to the left of the mitral orifice, and behind the left posterior sinus, with which it is closely attached. It gives insertion to numerous fibres from the left ventricle.

3. A strong fibrous half-ring or loop (C C) is situated in front, and to the left of the root of the aorta, and stretches from the left to the central fibro-cartilage, with both of which it is intimately incorporated. This tendinous half-ring is divided into two layers. The posterior or inner layer is united to the anterior and left posterior sinuses of the aorta, and gives insertion to muscular fibres from the left ventricle. The anterior and outer layer gives attachment to numerous fibres from the *conus arteriosus*, and from the left ventricle. The left and central fibro-cartilages (A B), and this connecting fibrous loop, form an united and powerful fibrous structure.

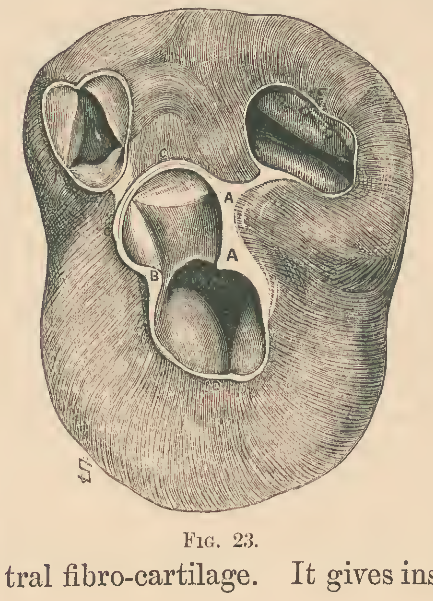


Fig. 23.

4. The tendinous ring of the mitral orifice (D) is united at one extremity to the left, and at the other to the central fibro-cartilage. It gives insertion to fibres from the left ventricle.

5. The tendinous ring of the tricuspid orifice (E) is attached at both ends to the central fibro-cartilage. It gives insertion to numerous fibres from the right ventricle

6. A fibrous ring surrounds the origin of the pulmonary artery (F), which is slightly connected to the fibrous half-ring of the aorta.

Fibrous pads rest upon the muscular floor of each of the sinuses of the pulmonary artery, and upon the muscular structure which gives support to the anterior and left posterior sinuses of the aorta. Numerous muscular fibres are inserted into these tendinous pads, which form the floors of their respective sinuses.

These various fibrous structures of the base are all associated together. They form, in fact, if we keep out of view the fibrous ring of the pulmonary artery, one common fibrous structure, which surrounds the aortic, the mitral, and the tricuspid orifices, which rests upon the bases of the left and right ventricles and their septum, and which gives a general insertion to the muscular fibres of both of those cavities, and a general origin to the muscular fibres of both auricles.

The Muscular Structure of the Left Ventricle, examined from within (Fig. 24).—When a section is made anteriorly through the right ven-

FIG. 24.

tricle (A) and the septum (B) into the left ventricle, the posterior aspect of that cavity is fully exposed, and the two papillary muscles are brought into view, resting upon and incorporated with its walls.*

The two papillary muscles lie side by side on the posterior wall of the ventricle, the whole of which they occupy (Fig. 24, 25, C D). The left muscle (D) is solid, massive, and perpendicular. Its truncated extremity and body are connected with the whole base of the ventricle, including the origin of the aorta (E), by strong diverging fibres (F), which are inserted into the tendinous ring and the two fibro-cartilages (E I). It interchanges fibres freely along its whole left border with the fleshy columns of the septum (G), and along its whole right border (H H,) with the right papillary muscle, the two muscles being thus incorporated where they adjoin.

The right papillary muscle (C) is straggling, oblique from right to left, and pointed. It is reinforced by bands of fibres along its whole right margin from the right portion of the tendinous ring, the right fibro-cartilage, and (L L) the right portion of the septum, and it gives off many fibres (M M) which pass into the septum, intermingling with those that go from the septum to the muscle (L).

Thus both papillary muscles blend with each other where they adjoin; send diverging fibres to the tendinous ring and two fibro-cartilages; and interchange fibres with the septum and body of the ventricles. It will be seen, therefore, that a complete unity is established between the two papillary muscles, and the base, walls, and apex of the ventricle. The papillary muscles are therefore truly a portion of the walls of the ventricles, and their contraction and that of the walls are not so much simultaneous as one common contraction.

The superficial fibres of the left papillary muscle, the adjoining fibres of the right papillary muscle, and the fibres of the left side of the septum, converge to form a twisted band or cord of fibres (O), which passes out of the ventricle at the apex, where it becomes superficial, which takes a direction from left to right, and winds round as it disappears with a bearing upwards and backwards. This superficial band of fibres takes a course over the back of the heart from apex to base, in a fan-shaped manner, diverging so as to cover the posterior longitudinal furrow, and the adjoining fibres right and left.

This cord of fibres (O) as it leaves the ventricle to the right, crosses in front of another cord or band of fibres (P P), which passes from the interior to the exterior of the ventricle, in a direction to the left, in the manner pointed out by Dr. Pettigrew.

The fibres which form this posterior cord (P) come from the right portion of the right papillary muscle (C), and (L) the adjoining part of the septum. In addition, however, to these fibres, the posterior cord is supplied by a fan-shaped layer of fibres from both papillary muscles and the left part of the septum, which bear to the left as they pass out of the cavity (P). They then become superficial, and wind round the front of the left ventricle, being distributed partly to the exterior, partly to the body of both ventricles.

A remarkable series of five or six fan-shaped layers (Q) may be seen in Fig. 24, which lie one behind the other, the foremost of them being

* I made the drawings of the muscular structure of the ventricles by tracing the outlines of the intimate structure on a piece of glass placed over the preparation. This method, which has recently been employed in Germany, is the same, substituting glass for lace or muslin, as that by which I made the drawings for this work, and for my paper on the Position of the Internal Organs, and the figures, many of which are minute, that illustrate my paper on the Mechanism of Respiration, in the "Philosophical Transactions" for 1846. Dr. Hodgkin, who advised me to adopt this plan, saw Benjamin West make use of it in his studio, and to him it had come down, according to tradition, from its inventor, Leonardo da Vinci. I cannot, however, find any account of it in that great master's work on painting.

immediately behind the posterior emerging cord (P) just described. Like that cord, these successive layers are composed of converging fibres from the left and right papillary muscles. The whole of these converging layers of fibres wind round the heart, each in front of the other, and as they do so, they diverge (R), ascending towards the base, and disappear in the body of the ventricle.

FIG. 25.

The Muscular Structure of the Right Ventricle, examined from within (Fig. 26).—In order to examine this structure, the ventricle was laid open by dividing, first the free wall, close to the septum, from base to apex (A A), and then the *conus arteriosus* (B B), and pulmonary artery (C), close to the base of the left ventricle.

FIG. 26.

The muscular structure of the right ventricle does not present the remarkable symmetry of that of the left ventricle, which is adapted to the cylindrical cone-like form of the cavity. The papillary muscles, the intricate fleshy columns which interlace so as to form numerous cells, and the muscular fibres of the right ventricle, are adapted to the remarkable muscular cone leading to the pulmonary artery and to the form of the cavity, the posterior wall of which is convex, being formed of the septum, while its anterior or free wall is concave. The anterior papillary muscle is attached to the anterior wall, while the superior and inferior papillary muscles are incorporated with the posterior wall of the ventricle.

The anterior papillary muscle (D) projects into the cavity from the middle of the anterior wall. During the systole, as I have already stated, the anterior wall of the right ventricle contracts from all sides towards the anterior papillary muscle, which is itself in a state of rest. The base, therefore, of the ventricle, the apex, the pulmonary artery, and the septum all move towards that muscle, when the cavity contracts.

A large and remarkable fleshy column (E) extends from the base of the anterior papillary muscle across the cavity of the ventricle to the septum, where it forms a portion of the superior papillary muscle. The fibres that are connected with the base of the anterior papillary muscle are connected also with the root of this column, which forms a bridge of connection between the anterior and the superior papillary muscles, and between the anterior wall of the ventricle and the septum.

The fibres (F), from the anterior papillary muscle to the pulmonary artery, ascend in a direction almost perpendicular; while those (G) to the apex descend in a direction from right to left. These ascending and descending fibres form, therefore, with each other a rather obtuse angle; and as the papilla (D) projects inwards, the papillary muscle, taken in conjunction with those fibres, assumes a pyramidal form.*

The fibres (FF) from the anterior papillary muscle to the *conus arteriosus* and pulmonary artery are very numerous, and are attached to the muscle from its base to its papilla. At first those fibres run parallel to each other; but as they ascend they diverge, so as to surround the whole cone as it approaches the pulmonary artery. Finally they are inserted into the tendinous ring of the pulmonary artery, and, chiefly, into the tendinous pads upon which the three sinuses (CCC) of the artery rest. The fibres to the left anterior sinus go directly upwards (F). Those to the right anterior sinus diverge in an angular manner forwards and to the right, and those to the posterior sinus diverge backwards and to the right, some of them passing as they ascend into the septum. These fibres are in several layers, one outside the other, and as they approach the pulmonary artery, each of the longitudinal layers (F) is associated with a transverse layer of fibres (HH) which runs in the direction of the circuit of the *conus arteriosus*. These transverse fibres extend some way into the cone, from its mouth at the pulmonary artery. The arterial cone, or infundibulum, is consequently there composed of circular and longitudinal bands of fibres, which are woven in and in with each other, like a circular piece of basket or wicker-work.

Numerous fibres (G) descend from the anterior papillary muscle to

* When looking at Fig. 26, it must be borne in mind that the whole anterior or free wall of the right ventricle is reflected backwards or to the left, in the form of a large square flap (CBLA). Consequently all those parts that look outwards or to the left, in the reflected flap in the drawing, look inwards or to the right, when the anterior wall of the ventricle is *in situ*.

the apex and the septum at the posterior longitudinal furrow. These fibres, when unravelled from within outwards, present themselves in radiating layers (GI). The inner or deep fibres (GG) descend towards the apex, while the outer or superficial fibres ascend towards the base, the intermediate fibres taking an intermediate direction.

Towards the base of the ventricle, at the tricuspid aperture (L), the inner fibres of the anterior wall are arranged like a net, with large irregular meshes (KK). These net-formed fibres descend obliquely, and are merged in a group of transverse spiralising fibres, situated just above the anterior papillary muscle, with which it is connected.

By the combined action of these various fibres, during the systole of the heart, the anterior or free wall of the right ventricle contracts from all directions upon the anterior papillary muscle as a centre, in the manner already described.

The posterior wall of the right ventricle is formed by the convex anterior surface of the septum. This surface is comparatively smooth. The superior papillary muscle (PE) is, so to speak, latent, being mainly embedded in the posterior wall of the ventricle. The only prominent portion of that muscle is the strong column (E), which stretches across the ventricle from the anterior to the superior papillary muscle. The inferior papillary muscle (OO) is comparatively prominent, and although it is seated upon the posterior wall, close to the longitudinal furrow, it has also connections with the free wall of the ventricle. A considerable portion of this muscle is, however, embedded in the posterior wall (OQ).

Ascending fibres from the superior and inferior papillary muscles, are inserted into the great central fibro-cartilage. The descending fibres from the same structures, and from the intervening portion of the posterior wall of the ventricle (QQ), when they reach the anterior longitudinal furrow, double upon themselves, and so pass from the posterior wall or septum to the anterior wall. These fibres from the posterior wall, as they pass to the anterior wall, and those from the anterior papillary muscle cross each other where they meet, and are interwoven so as to form an imperfect wicker-work structure (QG).

By far the greater number of the fibres of the free wall of the ventricle, when they reach the posterior furrow, pass directly over the septum, and are incorporated with the fibres of the left ventricle. The majority of these fibres are shallow (R); but some of them are deep (S), so that they may be traced into one of the papillary muscles and the inner walls of the left ventricle.

A certain number, however, of the fibres of the free wall, when they reach the longitudinal furrow, bend upon themselves (TT), and pass behind or into the inferior papillary muscles, and that portion of the septum which forms the posterior wall of the right ventricle.

Examination of the Muscular Structure of the Ventricles from without.—After the thin superficial layer of the muscular fibres of the heart is stripped off, it is easy to separate the subjacent fibres from each other in a succession of layers, which imbricate one over the other. If we examine these fibres on the posterior aspect of the heart (Fig. 27), beginning at the base, and unravelling them from right to left, we find that over the right ventricle and the longitudinal furrow (AB), they overlap each other in a succession of layers, somewhat like the capes of a coachman's great coat. The right portion of each of these layers is superficial to the one below it. As, however, the layer proceeds from right to left, it twists upon itself, and at length dips underneath that layer, to which it was superficial at the beginning of its course. Each band of fibres, where it turns upon itself, is riband-like in form, and it expands towards either extremity, right and left, owing to the radiating divergence of the fibres, so as to present a fan-like structure.

FIG. 27.

FIG. 28.

These layers of fibres are easily separated from each other at the base, along the posterior longitudinal furrow where they are inserted, one below another, into the central fibro-cartilage (A). Some of the layers end in the fibro-cartilage; but others, that pass over the furrow close to the base, send an off-shoot of fibres to the cartilage, so that those layers present the shape of the letter T or Y (A). When this angular off-shoot is traced, it is found to be formed by fibres which come both from the right and the left.

The fibres along the furrow (B), at about an inch from the base, are no longer readily split into layers; for there the fibres of one layer communicate with those of another layer, both upwards and downwards (Fig. 27). This intercommunication is particularly marked where the branches of the artery dip into the walls, and is probably connected with an arrangement to guard the vessels from the pressure of the contracting fibres during the systole.

The distribution of the muscular fibres of the anterior walls of the heart, and of the anterior longitudinal furrow (Fig. 28), when unravelled from without inwards, is, in principle, the same as the distri-

bution of the fibres of the posterior walls. The anterior fibres, traced from left to right, present themselves in layers or bands, which turn upon themselves at the anterior longitudinal furrow A. These bands of fibres, like those of the posterior walls, where they turn upon themselves are riband-like in form, and they expand towards either extremity, by the divergence of their fibres, in a radiating direction.

Over the left ventricle, the higher layers of fibres, or those nearer to the base, are superficial to the lower layers, or those nearer to the apex. These fibres converge upon the longitudinal furrow, where they become band-shaped and horizontal. Thence the layers again diverge, and, twisting upon themselves, the higher fibres, or those nearer to the base, dip under the lower fibres, or those nearer to the apex.

THE SOUNDS OF THE HEART.

I made many observations, with the valuable assistance of Dr. Broadbent, on the sounds of the heart in the dog and in the donkey, that organ being exposed when the animal was under chloroform.

We found that the second sound was most loud and sharp over the arch of the aorta, where the first sound was also heard, the second being three times as intense as the first. The second sound was only half as loud over the pulmonary artery as the aorta, the first sound being equal over the two vessels.

Over the whole right ventricle the first sound was louder than the second. The first sound was, at the beginning and during its course, rather rumbling in character; but it ended in an accent or sharp sound. It was of uniform character, and equally loud, over the *conus arteriosus* close to the pulmonary artery, over the base near the tricuspid orifice, and over the lower border of the ventricle, where it was occasionally of a ringing character. This equal diffusion of the sound over every part of the ventricle demonstrates that the cause of the sound is not concentrated upon any one valve or outlet, but is spread over the whole cavity. The second sound was generally audible, though feeble, over the right ventricle.

Over the left ventricle, also, from base to apex, the first sound began and continued with a rumble, and ended with an accent or sharp sound. It was carefully noticed that this accent corresponded with the precise end or stop of the contraction of the ventricles, when a marked, but not strong shock of reaction was felt over their walls.

The second sound was always coincident with a second impulse or sharp shock felt over the arch of the aorta and pulmonary artery, and not over either ventricle. The loudness of the second sound corresponded with and varied exactly in the ratio of the strength of the second impulse, the sound being loud where the impulse was strong, faint where it was feeble, and almost or quite inaudible where it was imperceptible. The second impulse could be felt strongly at the top of the arch, feebly along its descending portion, not at all over the lower thoracic aorta, and scarcely or feebly over the innominate artery.

The blow made by the return flow of blood from the arteries back upon the arch and valves of the aorta was the common cause of the second shock and second sound. The cause of the second sound is not therefore limited to the semilunar valves, but is common to them and the walls of the arch of the aorta.

Again, the second sound is not due to the closure of the semilunar valves, but to the shock of the return flow of blood upon those valves when already closed. A little consideration will make it evident that the sigmoid valves must come together at the very end of the systole, otherwise blood would at once flow back into the ventricle, during a period that, as M. Marey has shown in his important work on the Circulation of the Blood, precedes the second sound by one-tenth of a second, and coincides with the short pause. During this short pause between the first and second sounds, the walls of the arteries, just charged to the full by the systole, return upon themselves and drive the blood forwards into the smaller vessels, and backwards upon the arch and aortic valves; those valves being already approximated by the elasticity of their under surface, in the manner demonstrated by Dr. Markham, and by the pressure of the blood upon their upper surfaces.

In estimating the cause of the first sound, we must bear in mind that it is equally loud over the whole of the ventricle, that it begins and continues with a rumble, and that it ends with an accent or sharp sound, which is coincident with the extreme contraction of the cavity and with a faint shock felt just then over the ventricle. If the blood be shut off from the heart by tying the venæ cavæ, the second sound is generally extinguished, and the first sound is rendered so feeble as for a time apparently to disappear. There are, however, distinct remains of the first sound. The accent appears to be quite lost, and the rumble is materially weakened, but a feeble rumble is still distinctly heard during each contraction of the ventricle.

It is clear, therefore, that the systolic accent and the louder share of the rumble are due to the action of the blood on the walls as well as the valves of the ventricle. The accent, which any one may hear by listening over the healthy heart, is undoubtedly synchronous with the end of the systole. At that time the semilunar valves necessarily come together and are pressed against each other by the blood contained in the arch. As the expulsion of the blood must then stop, the fluid remaining in the ventricle probably causes a faint shock or accent at the end of the systole, which shock would not be concentrated upon the valves, but, like the accent, be diffused over the whole cavity, the pressure of the blood being equal in every direction.

The part of the rumble that is still audible when the blood is shut off, is doubtless due to the muscular rumble of the contracting walls of the ventricle.

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